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Familiarity with a Melody Prior to Training Increases Children's Piano Performance Accuracy

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Dedication

This treatise is dedicated to my parents, Katherine Donnelly and Dean Kenneth Goins, Jr., for their constant love and support, and to my grandparents, Tom and Lois Donnelly, for encouraging love of learning and pursuit of knowledge.

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Familiarity with a Melody Prior to Training Increases Children's Piano Performance Accuracy

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The purpose of this study was to examine the effect of familiarity with the sound of a melody on children's performance of the melody following brief training. A secondary purpose was to explore the effects of varied sound feedback during testing on children's performance accuracy.

Children (*N* = 97) in kindergarten through fourth grade were taught to play a short melody on an electronic piano keyboard during brief, individual training sessions. Half of the children listened to the test melody prior to training for approximately eight minutes during music class over a period of two weeks. The remainder of the children had not heard the melody prior to training. Immediately following training, children were administered performance tests, during which they attempted to play (1) the first two measures of the test melody under three conditions: with the keyboard sound audible; with the keyboard sound turned off; and with the starting note lowered from C to B, thus altering the intervals in the melody, and (2) all four measures of the test melody. Performance accuracy was assessed in terms of the number of correct notes and the number of correct measures played in each test condition. The children also completed two standardized tests of memory for digit spans and hand motion sequences.

Children who were familiar with the melody played significantly more correct notes and correct measures in the four-measure test than did children who were not familiar with the melody. Performance accuracy increased with increasing grade level. The three tests of the first two measures revealed no significant main effects, but there was a significant interaction between sound feedback and grade level, suggesting that attention to sound feedback changes with age. No significant correlations were found between performance accuracy and the scores on either standardized test of memory.

Familiarity with the test melody influenced children's ability to play the melody accurately following brief training. The lack of difference among the two-measure test conditions suggests that children can rely on their memory of the physical movement when sound feedback is not available.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Researchers in education, educational theory, child development, and motor learning contribute much to current music education practices. Developing instructional strategies for effective teaching has been a consistent focus of research in these areas. One effective teaching technique that has been identified in learning theories, music education research, and research in motor skill learning is that of modeling. Modeling has been defined as a process in which the learner attempts to imitate an observed action or skill performed by another individual (McCullagh, Weiss, & Ross, 1989) and the live or recorded presentation of anything that may later be imitated by an observer (Madsen, Greer, and Madsen, 1975).

Modeling has been used by educators and researchers in many contexts.

> A model can convey useful information about appropriate behavior. A model can quickly and efficiently convey what to do or give a precise image of the task demands…It is commonly thought that observing a model facilitates performance through at least two methods: by providing information about the appropriate or inappropriate response and/or changing the motivational state of the observer. (Martens, 1974, p. 278)

According to Bandura's (1986) social learning theory, modeling provides learners with an accurate representation of the task to be performed, thereby allowing the learner to use that representation as a guide. Modeling allows learners to gain accurate information about the task to be performed, observe or hear appropriate responses, become motivated to perform the task, and engage in self-correction.

Visual and aural modeling are both vital to music learning. Influential music educator Shinichi Suzuki (1898-1998) believed in the importance of modeling when learning to play a musical instrument. Suzuki's approach incorporates fundamental teaching techniques that are inherent to excellent teaching. Suzuki taught using the “mother tongue” approach, applying principles of language acquisition to music learning, focusing on imitation of sound and repetition (Suzuki, 1983, p.2).

Suzuki’s teaching philosophy revolved around a belief that all children can learn music, learning at their own pace and finding joy in personal musical accomplishments and the musical accomplishments of others. He purported that musical ability could be developed through training and was not an inborn talent. He proposed the idea that, with training, all children had the potential to learn a musical instrument (Suzuki, 1983).

Suzuki advocated for a parent-child-teacher triangle, with parents as an integral part of the learning process in the lesson and home environment. He encouraged music learning beginning at a young age. Additionally, he identified the importance of music listening, stressing the need for the parent to learn the instrument along with the child and for both parent and child to listen to recordings of their assigned repertoire and other excellent music in the home. He emphasized that frequent listening to models is an extremely important part of the music learning process.

Suzuki’s pedagogical principles were based upon his teaching philosophy. He believed in the importance of modeling, repetition, and sequential teaching, proposing that many thoughtful repetitions were necessary for mastery. He taught creative repetition, repeating skills from different angles to avoid monotony. He thought that “ability breeds ability” (Suzuki, 1983, p.6) and that students improve and gain fluency and mastery through repetition of familiar pieces while learning new repertoire.

In summary, Suzuki emphasized the need for sequential teaching and listening. Students first learn by rote, developing the ear through teacher modeling, group lessons and listening activities, recordings of repertoire, and listening at home. Familiarity with melodies to be learned is gained through hours of listening outside of the lesson. Repertoire is arranged sequentially, enabling students to master a concept through deliberate practice before moving to the next concept. Thus, a learning environment is created which allows students to develop familiarity with the instrument, learn correct technique, and a gain sense of musicality before note reading is introduced. As in language learning, learning the mode of communication (sound) precedes music reading and theory.

Scarce research literature exists on the use of the Suzuki method or modeling in Suzuki lessons. Duke (1999) and Colprit (2000) both investigated teacher behavior in Suzuki string lessons. Duke found that teacher performance (modeling) accounted for 27% of lesson time and teacher approximations (forms of modeling such as clapping, singing, counting, conducting) accounted for 9% of the lesson time. Colprit analyzed 48 violin and cello lessons taught by 12 expert Suzuki string teachers and found that 20% of all rehearsal frame time (lesson segments with specific targets) was devoted to teacher modeling, with teacher modeling occurring at a rate of 2.21 models per minute and teacher approximations at a rate of .55 approximations per minute (Colprit, 2000).

Additionally, the effect of Suzuki lessons on children's behavior has been investigated. Scott (1992) studied the attention and perseverance behaviors of preschool children enrolled in Suzuki violin lessons and other activities. She found that children enrolled in either individual Suzuki violin lessons or individual and group Suzuki violin lessons scored higher on attention tasks than did children in creative movement classes, preschool activities, or children not involved in organized preschool activities. Children enrolled in Suzuki violin lessons also spent significantly more time on perseverance tasks than did children in the creative movement or preschool groups.

The Suzuki method is an established and recognized music teaching methodology. Teachers are trained in the Suzuki method, through workshops, summer programs, certification classes, and other continuing education opportunities. Books, magazines, websites, and research journals contain information about the value and educational standards of the Suzuki method. However, it is important to remember that the principles of effective teaching are the same across instruments regardless of allegiance to a particular method. For this study, the Suzuki method is reviewed because of the emphasis Suzuki teachers place on modeling during music instruction. The focus of the study is not on the Suzuki method itself, but on the effects of modeling as an instructional strategy in children's music learning.

Unlike the Suzuki string and piano methods, traditional piano method books rely on instructional strategies other than modeling to teach beginning students. Analysis of three popular beginning method books (Alfred *Premiere Prep Course*, Faber and Faber *Piano Adventures*, Hal Leonard *Standard Piano Library*) reveal virtually no emphasis on listening or modeling. For example, in the first practice guide given in the Alfred *Premiere Prep Course*, children are given four steps: they are asked to tap the rhythm in their lap and count aloud, play the piece on the closed keyboard lid while saying the finger numbers aloud, play and count aloud, and then play and sing aloud (Alexander, Kowalchyk, Lancaster, McArthur, & Mier, 2005). No mention is made of listening to a model or thinking about the sound of the melody.

The use of finger numbers is a common instructional strategy presented in the three previously mentioned beginning piano methods (Alexander *et al*., 2005; Faber & Faber, 1996; Kreader, *et al*., 1996). Each finger is given a number (thumb is always 1), with numbers associated with specific notes on the piano for that piece of music. In all three methods surveyed, finger numbers are used to help children identify which note to play. Finger numbers are introduced immediately after basics such as how to sit at the piano and appropriate hand position, with all three methods displaying a hand diagram with finger numbers. In *Piano Adventures* (Faber & Faber, 1996), these hand diagrams are used with beginning pieces to show the fingers used for each piece. *Piano Adventures* also begins by presenting finger numbers with arrows indicating the direction of notes on the piano (ascending or descending). The other two methods use off-staff notes combined with finger numbers and directional arrows.

Non-Suzuki piano teachers and Suzuki trained music teachers share the goal of developing musicians with excellent technique and musicality. Their approaches, however, may differ. Piano teachers not using the Suzuki method tend to use instructional strategies such as finger numbers to teach note and interval reading from the onset of lessons. Less emphasis is placed in traditional piano method books on developing listening skills and aural understanding, and individual teachers must incorporate modeling and ear training. Teachers trained in the Suzuki method use modeling and listening to develop aural understanding, long before the introduction of note reading.

Some controversy exists among music teachers as to the advantages and disadvantages of delaying note reading and relying more on aural skills to learn music. Practitioner journals such as the American Music Teacher and Music Educators Journal describe this controversy. Recognized piano teacher Jane McGrath (2003) wrote,

> Students who play well by ear have a wonderful gift the teacher should acknowledge as just that—a "gift" and special ability. They need to know, however, the importance of also reading music in much the same way as everyone learns to read books. (p. 80)

More traditional piano teachers have criticized the Suzuki method because of its emphasis on delayed note reading and repeated use of modeling. However,

> Any movement or idea, in the hands of so many followers, is bound to face dangers, pitfalls, and obstacles. In the early days, the weaknesses of the Suzuki method were seen by skeptics to be the inability of students to read music and their unmusical, robot-like playing. As the years passed, however, it became clear that, in this as in any method, the student is a product of the teacher as well as the

> system; students will read if taught to read and will develop musically if given the right environment. (Kendall, 1996, p. 46)

Additionally, the use of models in the Suzuki method has been questioned. In response to the issues involved in using recorded models, Kendall wrote,

> Using tape recorders in lessons, for home practice, for accompaniments, and for repeated listening to repertoire to be learned is a vital part of the teaching method. Again, skilled teachers must use discretion not to push too far in using one tape or recording as an exact model to be duplicated in teaching advanced literature. (Kendall, 1996, p. 46)

Excellent music teaching relies on sequential presentation of the fundamental components of music, regardless of the instrument or method. It is only logical to assert that the teacher is more influential than the specific method in effecting change in student behavior and that combining ideas from a variety of teaching methods leads to a well-rounded teaching foundation. Research is needed to focus on the use of modeling in music instruction and the effect of modeling on the learning and performance of children of different ages. Furthermore, research is needed to study the effect of aural familiarity with a melody, developed through repeated listening, on children's ability to play the same melody on an instrument.

PURPOSE OF THE STUDY

The Suzuki method incorporates modeling as a fundamental instructional technique for music learning. Modeling is also a fundamental instructional technique in motor learning (e.g., SooHoo, Takemoto, & McCullagh, 2004; Weeks & Anderson, 2000). Even though motor accuracy and precision are vital to music performance, and music learning often starts at a young age, little research has been done on the acquisition of motor skills in young children. Modeling plays an important role in both music learning and motor learning in general, but little attention has been given to connecting research on the use of modeling in motor skill acquisition with research on modeling in music learning. Is modeling an effective teaching technique for children learning to play a simple melody on the piano? Are children of different ages influenced by models in similar ways? The present study focuses on these questions by examining the effect of familiarity with a model on children's motor skill acquisition in a piano task.

Auditory modeling, e.g., a teacher demonstrating a musical passage, is a component of music teaching. Similarly, auditory models are sometimes used in studies of motor learning. For example, in a motor task such as tapping a pencil on a table, an auditory model could be used to demonstrate the desired length of each pencil tap. Auditory modeling can affect music and motor learning. Because the nature of music generally involves sound and playing a melody on the piano requires the use of fine motor skills, this study examined the effect of sound feedback in motor learning. A secondary purpose of the study was to explore the effect of different types of sound feedback on motor accuracy in a piano task.

QUESTIONS

The following research questions were posed:

1. Does familiarity with a musical model (recording) improve children's note sequence accuracy when performing a simple melody on the piano after one training session?
2. What differences in note sequence accuracy exist in children of different ages when performing a simple melody after one training session?
3. How does different auditory feedback (i.e., the presence of sound, absence of sound, or transposed sound) affect note sequence accuracy in the performance of a newly learned melody?

LIMITATIONS OF THE STUDY

In the present study, I taught children in kindergarten through fourth grade to play the test melody by rote on the piano in a single individual training session. Following the training, tests were administered to determine differences in note accuracy in the performances of children who were familiar with the melody (those who listened to a recording of the test melody at the beginning and end of music class for eight sessions) and children who were not familiar with this melody. After a single training session, seven tests were administered. Five of the tests analyzed note accuracy and two tested basic memory abilities. Midi and videotape data were gathered.

Sequences of notes were analyzed for accuracy. Two dependent variables were selected: number of correct measures and number of correct notes played in a test immediately following the training session. These variables were considered appropriate for the present study given the limited training that the children were given (less than 15 minutes) and the characteristics of the stimulus (isorhythmic, two-measures long, composed of a total of 16 notes and 5 pitches). However, learning to play sequences of correct notes is only part of what learning to play a piece entails. Although correct notes are critical in musical performance, other elements such as correct rhythms, phrasing, nuances, and expression are integral components of every performance. Whether aural familiarity with the music prior to practice affects how children play these or other aspects of the piece is unknown.

Testing took place immediately after training. Therefore, the performance tests were tests of immediate retention. Results do not indicate how children in the familiar and unfamiliar groups would perform at later times on tests of recall and retention. This problem is certainly relevant for teachers who emphasize long term goals and objectives.

Perpetual Motion from the *Suzuki Violin Book One* was determined to be an appropriate melody for children to learn in one session. However, only the first 16 notes of the actual piece were used and transformed into four measures. Using a complete piece of music, with added musical expression, would have been preferable as the task would have resembled a more realistic music learning situation.

All children attended the same school in an affluent school district. Economic and racial diversity were limited.

All children were taught to play the test melody using the same structured sequence of researcher model and subject performance trial. For the present study, a structured sequence was necessary, for reasons outlined in the methodology. However, it is clear that the teaching protocol selected did not allow for individual pacing differences. Using a subject directed sequence where number of performance attempts are determined by initial accuracy and amount of repetitions needed to be accurate during training should be considered in future studies.

Chapter 2: Review of Literature

Motor skills play an important role in music learning and music making. The essence of much music technique requires the skillful execution of gross and fine motor skills. Expert pianists perform difficult technical passages with precise finger, hand, and arm motions that require years of development and practice. The same holds true for other instrumentalists: excellent technique requires skillful motor coordination. The motor control and accuracy required for music performance is acquired through training and practice.

In studies of motor learning, emphasis is placed on the effect of practice in skill development. Generally, learning is measured through increases in performance speed or performance accuracy. For example, measurements of motor accuracy can be based on whether a movement or sequence of movements is right or wrong. Often, however, more detail is needed to determine a precise level of movement accuracy. To establish this level of detail, different measurements of movement errors are used. Measurements of error can determine the average deviation in response (constant error), the inconsistency of the response (variable error), the overall error (root-mean square error), and the overall accuracy (absolute error) (Schmidt & Lee, 2005). Accuracy can also be measured by amount of time on target, for example, holding a stylus in contact with a rotating target (Schmidt & Lee, 2005). For some tasks of motor learning, skills are measured by the magnitude of the movement. Examples of measurements of magnitude are the distance a ball is thrown or the amount of weight a person lifts. The use of one type of measurement or another depends on the purpose of the study. For example, in a study of children's ability to throw a bean bag to a target location, Wulf (1991) analyzed accuracy through measures of absolute error (how close the child was to hitting the target), variable error (the inconsistencies of the child's practice trials), and root mean square error (a measure of the child's overall success).

Another common way of assessing motor skills is by measuring speed. This is done by measuring (a) reaction time, the amount of time from the arrival of a stimulus to the beginning of the response, and (b) movement time, the interval of time from the initiation of the response to the completion of the movement. Overall response time is also measured by adding the reaction time to the movement time (Schmidt & Lee, 2005). Timing can be relative or absolute. Relative timing refers to the ability to perform timings in relation to a whole sequence (e.g., the same ratio of timing from one key press to the next regardless of overall speed). Absolute timing refers to the overall speed of the sequence (e.g., the same amount of time from the beginning to the end of the sequence).

Understanding how motor skills are acquired and the mechanisms involved in the brain and body during practice is relevant for music learning and teaching. The following section reviews research related to the processes that underlie motor learning with adult subjects, focusing on the acquisition and consolidation of motor skills, behavioral and neural changes during skill acquisition and consolidation, and the effect of practice. The review of motor learning in adults was considered imperative for the development of the present study for the following reasons: (1) Research on adults' acquisition of motor skills has provided the basis for research on children's performance in motor tasks. Studies conducted with children are quite recent and are often replications of those conducted with adults. The review of the original studies with adults allowed for a more comprehensive review of the studies with children. (2) The literature on adults' performance of motor tasks is extensive and comprehensive while that of children is limited both in quantity and scope. For example, the use of modeling and aural feedback in the learning of a motor task, two important components of the present study, has been scarcely investigated with children. (3) In order to understand the methodology and questions posed by studies directly related to the focus of the present investigation, it was necessary to review some of the most common questions of research in motor skill acquisition. Thus, a review of literature on indirectly related topics such as motor consolidation, interference, and neural changes during motor skill acquisition was included in this chapter. (4) Decisions about the methodology used in the present study were based on previous research conducted with children and adults. For example, the training protocol followed when teaching the children to play the melody was based on the methodology and results of research on types of practice. A substantial section of this chapter focuses on this research conducted with both adults and children.

Motor Skill Acquisition

Across many areas of expertise, the effect of practice is obvious: practice generally improves motor skill performance. Professional athletes train daily to refine and maintain their skills. Expert musicians practice daily to develop and maintain motor dexterity, listening, and critiquing skills.

The process of motor skill learning is usually divided into two stages: acquisition and consolidation (Floyer-Lea & Matthews, 2005; Karni, Meyer, Rey-Hipolito, Jezzard, Adams, Turner, & Ungerleider 1998; Savion-Lemieux & Penhune, 2005; Walker, 2005). Physical practice of a skill is part of the acquisition stage of motor learning. During initial practice sessions, rapid performance improvements occur as subjects acclimate to novel skills. This can be observed in everyday activities such as a child's throwing a ball toward a target or a musician's practicing a scale passage. This acquisition stage usually involves exposure to the task and relevant training. Acquisition involves fast skill learning, with obvious immediate improvements within initial sessions.

Imagine, for example, a child reaching for and grasping an object. The arm and hand movements involved in this reaching task are stored in the brain as a Generalized Motor Program (GMP). The GMP represents the learned relationships between movements in a pattern and is thought of as memory for general task requirements. However, most tasks have specific requirements for successful completion. Reaching and grasping a small toy is different than reaching and grasping a large book. Motor schemata are the rules or specific requirements needed to perform a particular task. In many studies of motor skills, the GMP is measured by relative timings and forces of individual movement segments that comprise a skill. The GMP is the foundation for generating responses within a class of movements that share the same features (e.g., relative timing or relative force). The parameters represent the actual values, timings, and force needed to perform a specific motor skill (Shea, Wright, Wulf, & Whitacre, 2000; Shea, Wulf, Park, & Gaunt, 2001; Wulf and Shea, 2002). Take, for example, a specific rhythmic pattern in a musical composition. When the tempo is changed slightly by speeding up or slowing down the motor movement, the rhythm of the movement stays the same. The parameter of tempo is altered, but the actual GMP for the movement does not change.

Acquisition of a skill changes the brain. From the first attempt of a motor skill to full proficiency of the skill, numerous cognitive and muscle functions are engaged. Although behavioral evidence shows that simple motor skills improve with practice (Fischer, Hallschmid, Elsner, & Born, 2002; Karni *et al.*, 1998; Karni, Meyer, Jezzard, Adams, Turner, & Ungerleide, 1995; Korman, Raz, Flash, & Karni, 2003; Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002), understanding how repetition of a motor sequence results in performance improvements is not fully understood. Current brain research suggests that improvements are due to the development of and changes in the neural representation of the motor skill (Karni *et al.*, 1995; Pascual-Leone *et. al*, 1995; Ungerleider, Doyon, & Karni, 2002).

The human brain is plastic, with an impressive ability to adapt and change. Training and repetition of specific skills results in lasting changes in neuronal properties, such as the structure or function of neurons in response to a stimulus (Walker, 2005). Different regions of the brain are involved and activated at different stages of skill learning. During acquisition, the cerebellum, basal ganglia and primary motor cortex (M1) are activated (Karni *et al.*, 1995, 1998; Savion-Lemiux & Penhune, 2005). As new motor skills are learned, the brain's internal representation of the newly practiced sequence is enlarged and synapses are strengthened (Altenmüller, 2001; Karni *et al.*, 1998, 1995; Pantev, Engelien, Candia, & Elbert, 2001; Savion-Lemiux & Penhune, 2005; Ungerleider, Doyon, & Karni, 2002).

Observed changes in the primary motor cortex and other areas of the brain reflect this neural plasticity, suggesting that "skill learning can be mediated by discrete, experience driven changes within specific neural representations" (Karni *et al.*, 1998, p. 861). Practice of a new motor skill strengthens synapses and evokes a change in neural processing that continues to evolve with time, leading to a formation of the internal representation of the task in the brain (Karni *et al.*, 1998; 1995; Korman *et al.*, 2003). Through functional magnetic resonance imaging (fMRI) data, Karni and colleagues showed that daily practice of a sequential finger task over several weeks evoked a more extensive representation of the trained sequence in the primary motor cortex of the brain following training. Data also showed a change in the primary motor cortex from the beginning to the end of the initial scanning period, indicating that experience-dependent changes can be induced by a limited amount of repetitions within the first imaging session (Karni *et al.*, 1998).

In an experiment using two finger tapping tests, brain imaging showed that before practice, the tests evoked a similar neural response in subjects' primary motor cortex. After training on one sequence, the practiced sequence evoked a larger response in the primary motor cortex than the response evoked with an unpracticed similar sequence, or a sequence in the other hand (Karni *et al.*, 1995).

The rapid learning that happens during acquisition evokes changes in neural processing but occurs too quickly for actual structural changes to be taking place (Walker, 2005). There may not be enough time in acquisition for the synthesis of new proteins or the formation of new synapses. Rather, it has been proposed that this fast learning is simply a result of disinhibition, the unmasking of previously existing connections (Pascual-Leone, 2001; Walker, 2005).

Skilled performance is not a product of a single training session. Although large improvements are seen early in acquisition, brain imaging and behavioral data show that initial changes and performance improvements are retained through the slow learning process that follows, with incremental performance gains emerging with continued practice across days. A single training session can evoke immediate improvements in performance, but specific improvements can continue to emerge over longer periods of time (Karni *et al.*, 1998, 1995; Korman *et al.*, 2003; Pascual-Leone, 2001).

Mental practice also evokes changes in the brain. Pascual-Leone and colleagues found that mental practice of a five finger piano exercise produced the same changes in the cortical representation as did actual physical practice. Interestingly, physical practice combined with mental practice produced the largest performance changes. The effect of mental practice alone on brain activation provides interesting implications for music learning. Because mental practice activates the primary motor system in ways that are similar to physical practice, more mental practice could be used in place of physical practice to prevent injury, aid memory, strengthen musicianship, and vary practice techniques (Pascual-Leone, Dang, Cohen, Brasil-Neto, Cammarota, & Hallett, 1995).

An additional practice technique similar to mental practice is observation of a model. Observation demands less cognitive involvement than physical practice, as learners are not physically performing the task but instead are observing someone else performing the task. Studies show benefits of observation in the context of more complex tasks. When learners observe performances of a motor task, they can identify possible practice strategies and determine their efficiency and effectiveness. Observation of a model enhances efficiency by allowing learners to observe the complexities of a task before physical practice occurs. Therefore, learners engage in cognitive processing that may be less possible in early stages of physical practice (Shea, Wright, Wulf, & Whitacre, 2000; Wulf & Shea, 2002).

Motor Skill Consolidation

Not only does motor skill learning occur during active practice, but it continues during the time following practice in a process called consolidation. Through the process of consolidation, the internal representation of the practiced skill becomes less susceptible to interference and performance improvements are seen without additional practice (Karni *et al.*, 1995, 1998; Robertson, Pascual-Leone, & Miall, 2004; Savion-Lemiux & Penhune, 2005).

The process of consolidation transforms a new memory into a robust, stable memory, and explains the skill improvement or enhancement that occurs between practice sessions (Fischer *et al.*, 2002; Robertson *et al.*, 2004; Walker, 2005). Walker (2005) defines successful consolidation by the degree of stability of the memory and its resistance to interference. Performing new motor sequences can interfere with the consolidation of a previously learned sequence. Take, for example, a pianist practicing a difficult right hand arpeggio. Practice of a slightly different right hand arpeggio immediately after practicing the first arpeggio could interfere with consolidation, perhaps causing a decrease in accuracy or speed of the first passage. This type of interference causes performance of a recently learned skill to be compromised after a new, similar skill is practiced.

Consolidation occurs following the initial practice session and within rest periods greater than four hours (Brashers-Krug, Shadmehr, & Bizzi, 1996). Significant improvements are seen following sleep in task performance components such as speed and accuracy with no additional practice of the skill (Savion-Lemieux & Penhune, 2005; Walker, 2002, 2005). For example, Brashers-Krug and colleagues (1996) showed that in a finger tapping motor task, practice produced gains in speed and accuracy. When subjects were tested 24 hours later without further training, significant gains were seen in overall motor performance (Brashers-Krug *et al.*, 1996; Karni *et al.*, 1998; Shadmehr and Brashers-Krug, 1997; Walker, 2005). Stabilization occurs across time during periods of wake and sleep, resulting in task and performance maintenance and consolidation (Karni *et al.*, 1998; Korman *et al.*, 2003; Walker, 2005).

Walker and colleagues (2003) discuss the idea of reconsolidation of a memory, suggesting that reactivating a memory makes it labile and again vulnerable to interference and in need of further consolidation or reconsolidation. They describe the process of motor skill learning as a four-step process: initial acquisition, stabilization of the memory through wake-based consolidation, enhancement of the memory through sleep consolidation with performance improvements in speed and accuracy, and a fourth, new stage of learning where brief rehearsal of the learned skill returns it to a labile state vulnerable to interference and needing reconsolidation (Walker, Brakefield, Hobson, & Stickgold, 2003). Although more research is needed to determine exactly how interference and reconsolidation occur, these phenomena demonstrate the complexities and time sensitive nature of motor skill learning.

Practice

As evidenced through research in neurology and kinesiology, motor skill acquisition and consolidation depend on practice and the passage of time. Because the efficiency and efficacy of learning is maximized in a context that promotes higher cognitive involvement, it is important to understand how to structure physical practice to require more cognitive attention. Two commonly used forms of practice are (1) stable or blocked practice, in which one task version is practiced the same way for a number of repetitions, and (2) variable practice, in which several task versions are practiced in random order. Variable practice can involve practice of sequences with the same GMP but changing parameters, or practice of sequences with different GMP's in a random order (Magill & Hall, 1990). For example, hitting a baseball with curveballs and fastballs pitched in random order uses the same GMP but varying parameters. Playing tennis with a tennis machine releasing balls at the same speed to different places on the court would require the use of a forehand swing and a backhand swing, which use different GMP's. Current studies by Shea, Wulf, and Lai generally use the term variable practice to imply changing parameters and not changing GMP.

Stable and variable practice are both necessary for motor skill learning. Stable practice is needed to develop the GMP, as the stability directs attention to the overall movement structure pattern, thereby strengthening the formation of the GMP. In general, practice conditions that increase movement stability enhance GMP learning (Lai *et al.*, 2000). Additionally, stable practice is more critical when practicing complex tasks, as the similar repetitions allow learners to focus on correcting and stabilizing their movements. Stable or blocked practice must be combined with variable practice to develop parameter learning and successful generalization to new tasks.

Researchers have proposed different justifications for the use of variable practice, also referred to in research literature as a type of contextual interference. One explanation, the elaboration hypothesis, is that learners keep information relating to the preceding and upcoming differing trials in their working memory. If a learner is playing three different sequences on a piano in random order, she is remembering information about what she just played and relating it to what she will play in the next trial. Because trials are different during varied practice, demands on cognitive processing increase. As subjects relate information from trial to trial, they elaborate on their distinct memories of executing the GMP with different parameter specifications and the ability to transfer to new contexts is enhanced.

A different view of why variable practice facilitates success in motor skill learning proposes that learners keep mental representations or GMPs in their working memory and must then reconstruct the memory before each varied trial. This is called the reconstruction hypothesis. If a learner practices two piano sequences in random order, he must mentally reconstruct the memory of the correct movement for the next sequence before playing. In the reconstruction hypothesis, learners have to reconstruct more memories during variable practice than during blocked practice. The higher level of cognitive processing involved in reconstructing memories is proposed to aid learning (Wulf & Shea, 2002). In general, both theories are based on the idea that variable practice increases cognitive processing which enhances learning.

Different practice schedules are needed at different times to enhance learning. To effectively develop the GMP, stable practice is initially needed to develop high movement consistency. Consider a short yet complex right hand piano passage. In order to play the passage consistently and accurately, a pianist would need stable repetition of the passage to develop the basic motions and finger coordination. A stable practice schedule helps the learner to attend to the complexity of the movement instead of focusing on changing parameters of the task. Because of this attentional focus, fewer errors are made during acquisition with a stable practice schedule than with a variable practice schedule.

Variable practice is thought to be more effective when transferring motor skills to new, similar tasks. Although more errors are made during acquisition when practicing with a variable schedule, changing parameters demand higher cognitive functioning. Before each repetition of a task, learners must think about how their movements must be adjusted to account for the new or different task requirement and direct their attention to the changing parameters. Although more initial errors are made with variable practice than with stable practice, learners more successfully transfer their newly acquired skill to a similar task based on different parameters when they have practiced with a variable schedule (Lai *et al.*, 2000).

Giuffrida *et al.* (2002) studied the transfer benefits of stable, blocked, and variable practice schedules. Using a sequential finger tapping test, the stable group always practiced with the same timings and tempo. The blocked group practiced all trials in one block using the same timings and tempo but then changed the task for the next block. The variable group practiced three different tasks in each block, each task with different parameters but the same GMP. As demonstrated in other studies, the results indicated that a stable practice schedule enhanced GMP retention when the task parameters were the same. Practicing an exact reproduction of a movement program and parameters was beneficial when a single task was performed in the same way it was practiced, but varied practice schedules were better when task parameters changed. Additionally, a variable practice schedule was better when subjects transferred their skill learning to a task with a new GMP, showing that variable practice not only enhances the ability to adapt to different parameters, but also the ability to perform a new GMP that is related to a previously learned GMP (Giuffrida *et al.*, 2002).

When considering the benefits of stable and variable practice, it is logical to conclude that a combination of practice schedules is necessary to maximize learning. If learners are provided with stable practice early in training, they will develop and be able to reproduce a stable memory of the GMP. After the GMP is developed, variable practice will refine parameter learning and enable more successful retention and transfer to a new motor task.

Research on the effect of practice schedules on motor skill development has many implications for teaching and learning. In baseball, for example, young children could develop hitting abilities by playing T-ball, a beginning form of baseball where the ball is in a fixed position on a stand and the child hits off the stand instead of hitting a moving ball. This form of stable practice could be used to learn to consistently hit the ball. After the general hitting technique is learned and the performance becomes more consistent in this fixed position, the difficulty level could be sequentially increased through the use of a pitcher and variable practice.

In music learning, constant or blocked practice is often used initially to develop skills. The addition of variable practice after the initial GMP is developed would be beneficial for skill development and retention. In the learning of musical scales, for example, students could use slow practice of a specific scale to establish accurate notes, accurate fingers, good tone, and appropriate technique, and then use variable practice to transfer correct fingering, technique, and tone to different scales or articulations of the same scale.

Feedback

Feedback plays a prominent role in most learning situations. Feedback can be broadly defined as any "stimulus occurring coincident with or subsequent to a given behavior that a learner associates with the behavior" (Duke, 2004, p. 122.) In motor skill learning, frequency and type of feedback have been shown to influence skill acquisition. Specific feedback positively affects performance in the early stages of motor skill learning because it helps the learner decide how to adapt movements to create movement consistency. Once consistency is reached and the learner can successfully reproduce the skill, feedback can be less effective for performance (Lai *et al.*, 2000).

Determining when to give specific feedback (such as the distance away from the target or slowest finger transition) and when to give qualitative feedback (e.g."good", "correct") is important in motor skill learning. Lai *et al.* (2000) found specific feedback to be more helpful when error is large. Providing knowledge of results of accuracy resulted in enhanced performance when inconsistencies were prevalent. When inconsistencies were less prevalent, qualitative knowledge of results was sufficient. In other words, when mistakes are large, people need to know more specifically what they are doing wrong, but if mistakes are minimal, specific feedback is not as necessary. Specificity of feedback can also change based on learner level: A beginning level learner is less engaged in self-evaluation and benefits more from specific and frequent feedback, whereas a more advanced learner can self correct and needs less specific feedback.

Reducing the frequency of feedback can enhance the learning of a GMP for a simple task (Wulf & Shea, 2002). As the performance becomes more stable, learners start detecting and correcting errors without external feedback. This type of self-evaluation leads to more cognitive involvement and awareness of efficient and effective mechanisms to enhance learning. In complex tasks, frequent feedback is more effective (Wulf & Shea, 2002).

It is important to note that many motor skill studies have been conducted with simple tasks. The necessity for and type of practice schedules and feedback would be different with more complex tasks. The learning of more complex motor skills seems to benefit more from frequent and specific feedback until a predetermined proficiency level is achieved. This finding contrasts with simple motor task learning, with studies indicating that reduced feedback is more effective in simple motor task learning (Wulf & Shea, 2002).

In summary, practice is an essential component of motor skill learning that leads to increased brain activation and noticeable behavioral changes. Amount of practice and type of practice affect acquisition, consolidation, and retention of motor tasks. Combining stable and variable practice schedules seems to be most beneficial for skill learning. Frequency, amount, and type of feedback may offer different benefits depending on the task complexity. Mental practice and observational practice provide different strategies for learning, either by activating the brain in similar ways as physical practice or by allowing time for deeper processing and evaluation of successful performance techniques.

Research on motor learning in adults provides a foundation for the study of motor learning with children. Research with adult participants encompasses a wider range of motor skills and measurement than does research with children. By understanding how adults acquire, consolidate, and practice motor skills, we can gain a greater awareness of areas that should be studied further with different ages of participants.

The process of motor learning has been widely studied in adult learners, but motor learning in children has received less attention (Rule & Stewart, 2002). Although precision and accuracy in motor skills are imperative for instrumental music performance, little research has been done on the acquisition of motor skills in young children or the connection between motor skill acquisition and music learning. Most musicians start instruction early in life, making the study of children's motor skill development particularly important for the understanding of learning.

THE DEVELOPMENT OF MOTOR SKILLS IN CHILDREN

Motor skill development is a critical part of childhood. The amount of growth and learning that occurs between the time an infant learns to control head movement to the time a 5-year-old learns how to skip is substantial. Researchers have documented the average gross motor development of children, beginning with partial head control in a prone position at one month of age and leading to the development of crawling, walking, jumping, and skipping in successive months and years. In a recent study of infant and child motor development, Edwards and Sarwark (2005) identified average developmental achievements from age 1 month to 5 years:

- 1 month Partial head control in prone position
- 2 months Good head control in prone position, partial head control in supine position
- 4 months Good head control in supine, rolls over prone to supine
- 5 months Rolls over supine to prone
- 6 months When prone, lifts head and chest with weight on hands, sits with support
- 8 months Sits independently, reaches for toys
- 10 months Crawls, stands when holding on to support
- 12 months Walks independently or with hand support
- 18 months Developing handedness

- 2 years Jumps
- 3 years Goes up stairs alternating feet, stands momentarily on one foot
- 4 years Hops on one foot, throws ball overhead
- 5 years Skips, dresses independently

(Edwards & Sarwark, 2005)

Although both gross and fine motor skills are essential for successful development, more research focuses on the development of gross motor skills, with less research available that documents the development and acquisition of fine motor skills (Rule & Stewart, 2002). Early fine motor development is usually organized into four developmental categories: fist coordination, reaching, grasping, and manipulation. Typically developing children usually keep both fists tightly clenched in the first weeks of life, developing a tight grasp and then holding fists open around 3 to 4 weeks of age. They begin reaching and bringing toys to their mouths around 12 weeks, and they begin grasping and transferring objects from 16 to 20 weeks. Manipulation of objects begins around 24 weeks, with children beginning a thumb-forefinger grasp and then a pincer grasp (pinching an object between one or more fingers and the thumb) around 32 weeks of age (Viholainen, Ahonen, Cantel, Lyytinen, & Lyytinen, 2002).

Fine motor skills are essential for children to dress, eat, and manipulate necessary tools such as pencils and scissors. However, the nature of the experience with fine motor skills seems to be more important for development than the amount of time spent practicing the activity. In a study of the effect of the use of practical life materials such as tweezers, tongs, and spoons on kindergartners' fine motor skill development, results indicated that children who practiced with practical life materials performed better on a transfer task (picking up pennies and placing them through a slot in a can) than children who practiced fine motor skills with other materials. This improvement occurred with equal amounts of fine motor activity in the experimental and control groups. Improvement in performance depended on the nature of the activity practiced, not the quantity of practice (Rule & Stewart, 2002).

In music, the ability to accurately use and control fine motor skills is vital, with independent finger motion critical for skills such as playing pentascales on the piano or practicing fingerings on the violin. However, there is a lack of research documenting both the use of fine motor skills in music learning and the acquisition of fine motor skills via music learning.

When performing motor tasks, young children demonstrate inherently higher levels of variability in controlled motor movements than do adults (Deutsch & Newell, 2004; Takahashi, Nemet, Rose-Gottron, Larson, Cooper, Reinkensmeyer, 2003; Thomas, Yan, Stelmach, 2000). In tossing a bean bag at a target, for example, young children show more variation in the distances and speeds of their individual tosses than do adults, whose movements are more consistent. Children are less experienced with most motor skills than adults and generally show greater variability in performance.

High performance variability in the gross and fine motor skills of children has been observed in a variety of experimental tasks. Six-year-old children performing an arm extension task, grasping a lightweight robotic arm and extending their arm forward and back in a reaching motion, exhibited greater trial-to-trial variability than did adults who performed the same task (Takahashi *et al.*, 2003). Children ages 6 and 8 exhibited more variation than older children (ages 10 and 12) or adults when trying to sustain force, showing high levels of accuracy when trying to increase a force to match a peak target, but less accuracy when decreasing force to a low target (Harbst, Lazarus, & Whitall, 2000). Additionally, children exhibited more variation and error in bi-manual tasks than did adults (Smits-Engelsman, Van Galen, Duysens, 2004). Similar variation differences between children and adults have been observed in sustained finger contractions, speed in extending the arm towards a target, and in more prosaic tasks like writing, grasping, and striking a ball (Takahashi *et al.*, 2003; Thomas *et al.*, 2000; Deutsch & Newell, 2001).

Researchers studying information processing and motor learning have proposed that the high variability observed in children's motor movement is attributable to noise in the sensorimotor system that is gradually reduced as a result of maturation (Deutsch & Newell, 2004). This neuromotor noise theory was used to explain why younger children showed more variability than older children or adults in a task such as a bean bag toss. However, when examining 6-year-old subjects maintain a constant force with the thumb and index finger of the dominant hand in a pinch grip, Deutsch and Newell (2004, 2001) found countervailing evidence. They found that practice-driven changes in the structure of force output account for age related reductions in force variability that were attributed to practice, rather than to a decline in neuromotor noise.

Similar studies confirm that the relatively high variability in children's motor performance diminishes with practice. Takahashi *et al.* (2003) hypothesized that children's motor adaptive ability is strong despite inherently high movement variability. In tasks such as the previously mentioned arm extension task (extension and retraction of a robotic arm) and other motor tasks, children and adults show similar movement patterns and errors. Further, in a study of 6- to 12-year olds, practicing with the opposite limb enhanced learning of a novel throwing accuracy task (Lui & Wrisberg, 2005). Although children perform tasks slower and with more movement variability than adults, 6-year-old children especially tended to significantly reduce their spatial and temporal variability with practice (Takahashi *et al.*, 2003). Because practice of motor tasks helps children to reduce error, adapt to inherent variability, and improve performance, variability in performance cannot simply be attributed to the presence of more neuromotor noise (Wulf, 1991; Takahashi *et al.*, 2003; Thomas *et al.*, 2000; Deutsch & Newell, 2001).

Researchers have proposed that perhaps children's motor skills improve with practice because they are developing and refining an internal representation or mental model of the task, allowing them to be more accurate (Thomas *et al.*, 2000). The use of an internal representation seems to be important in understanding how actions become automatic. Adults tend to perform motor tasks such as picking up a glass or reaching for a book without thinking about each small step involved in the movement process. The internal representation for each action serves as a prescription for the movement and allows accuracy in most performances. This feedforward information processing strategy allows adults to direct their movements and prevent errors. Young children, however, use a less effective feedback strategy such as visual knowledge of results to correct their movements once errors occur.

Thomas and colleagues (2000) examined the fine movement control of 6 and 9-year-old children and adults using a rapid, point-to-point aiming movement (placing a pencil on a tablet and moving it straight towards a target stop). The movement used in this study could be divided into two categories: the initial ballistic phase that begins and directs the movement towards the target (primary submovement) and the final corrective phase in which adjustments are made in order to hit the target. The primary submovement was assumed to be under central control and directed by a motor program using a feedforward strategy, whereas the secondary corrective movement was controlled by task feedback. Results indicated that adults and children used these two movement phases differently. In more skilled adult performances, the majority of the movement was in the initial ballistic phase, with only minor corrections in the secondary phase. In the performances of younger children, however, the majority of the movement was in the corrective phase. The less skilled the performers (i.e., younger children), the earlier the transition from ballistic movement to corrective movement.

Thomas *et al.* (2000) determined that even children as young as 6 can increase the proportion of movement time devoted to primary submovements, increase the smoothness of their movements, and increase overall accuracy. Lazarus, Whitall, and Franks (1995) found similar responses that indicate the development of an internal representation in young children. In an isometric force tracking test, 5- to 7-year-old children, 9- to 11-year-old children, and adults attempted to track the movement of a target across a computer screen. Subjects needed to apply and adjust pressure with their finger to keep the computer cursor inside the target area. The development of a more accurate internal representation was noticed through the use of feedback and feedforward strategies in measuring lag time (amount of time subject was behind the target). Adults used a feedforward strategy to anticipate the target path and adjusted their force and time accordingly, whereas young children were less able to anticipate the target path and ended up correcting their force and time. In other words, adults anticipated and avoided errors but children were unable to anticipate errors, instead adjusting and correcting. With practice, however, a small percentage of the 5- to 7-year-olds began to switch from a feedback-based correction strategy to a more feedforward-based anticipation strategy.

Jansen-Osmann and colleagues (2002) found similar evidence for internal representation development in children and adults using an arm adaptation task. When a force was applied to the arm, pushing it in the direction of a target, subjects learned to use less arm motion to prevent overshooting the target. However, when the force was removed and the task was transferred to the other arm, adults and older children (ages 8 and 10) still undershot the target, indicating that they accurately remembered the model from the previous task. The youngest children (6-year-olds) could not adapt as quickly or accurately, perhaps indicating a lack of a stored representation of the task (Jansen-Osmann, Richter, Konczak, Kalveram, 2002).

Practice

Although children have high variability in their motor skill performance, practice does enable successful performance. Although improvements in accuracy, speed, and reaction time are often associated with age related factors (Goodgold-Edwards, 1984), practice improves performance regardless of age (Deutsch & Newell, 2004; Goodgold-Edwards, 1984; Fischer *et. al*, 2002; Karni *et. al*, 1995, 1998; Korman *et. al,* 2003; Walker *et. al*, 2002; Wulf, 1991). In order to understand how to organize effective music practice sessions, we must understand how practice affects performance of motor skills.

Different components are involved in the execution of fine and gross motor skills. In the game of tennis, for example, different motor movements are needed for a forehand swing as opposed to a backhand swing. As previously discussed in reference to adult motor learning, these different movements are stored in the brain as the Generalized Motor Program (GMP). The GMP represents the general motor requirements for a task, or the learned relationships between movements in a pattern. The body, arm, and wrist motions associated with a forehand swing are stored as a different GMP than those of a backhand swing. However, children and adults need more than general motor requirements to perform tasks. Tasks often have specific rules or requirements, termed parameters.

Because the GMP and parameters are likely stored as separate memories in the brain, it is logical to assume that adequate development of both would require different types of practice strategies. Research with adult subjects shows that GMP development is enhanced through a stable practice schedule, in which one motor task is practiced in the way it will be performed, that is, without changes in any parameter. Practice that stabilizes a motion, or makes it more consistent, with focused attention on the relationship of movements in the pattern helps to develop the GMP (Lai, Shea, Wulf, & Wright, 2000; Shea *et al.*, 2001; Whitacre & Shea, 2000). Although much of this research has been conducted with adult subjects, findings also apply to children's motor learning.

Motor skills used often in daily life require the learner to have not only a stable memory for a movement sequence which can be recalled and executed, but also the ability to transfer the learned skills to new contexts. The extent and degree of variation in practice has been shown to facilitate or hinder transfer of motor learning to a novel situation that requires a similar response. With a variable practice schedule, the learner may make more mistakes during task acquisition but achieves greater success when generalizing the skill to a new context (Magill & Hall, 1990; Lai, Shea, Wulf, & Wright, 2000; Shea *et al.*, 2001; Whitacre & Shea, 2000). The reason for this contrast between the decrease in immediate achievement and the increase in delayed transfer is due to the amount of cognitive involvement during acquisition.

The effect of variable practice in facilitating transfer has been studied with children. One study of children ages 10-11 found that a variable practice schedule was more effective than a blocked practice schedule in learning to toss a bean bag to a novel target. Children who used a variable practice schedule with changing parameters of bean bag weight and toss distance were more accurate at reaching a novel target distance with a novel bean bag weight than were children who used a stable or blocked practice schedule with fixed weight and distance parameters (Wulf, 1991).

Although research with adult subjects suggests that variable practice schedules are better for task retention and transfer than blocked or stable practice, research targeting differences between novice and expert performers presents implications for children's motor learning. Guadagnolli and colleagues (1999) studied the effect of practice schedules on novice or expert learners performing a golf putting task and found that novices who practiced with a blocked schedule performed better during retention than novices who practiced with a random schedule. The results were opposite with more experienced golfers: experts performed better in retention when practice followed a variable schedule.

In a more recent study, Guadagnolli and Lee suggest that "task difficulties create learning potential whose function differs according to the level of the performer, complexity of the task, and training environment" (Guadagnolli & Lee, 2004, p. 222). This implication that novices need blocked practice to acquire proficiency at a skill is important for future research with children's motor skill acquisition. Perhaps a variable practice schedule should not be introduced until a child has achieved a base level of proficiency (Magill & Hall, 1990). If children initially practice motor skills with a stable practice schedule, they may develop greater proficiency and reduce error, later making a variable practice schedule more effective for task generalization and transfer.

Feedback

Feedback or knowledge of results also affects children's motor response (Barclay & Newell, 1980; Goodgold-Edwards, 1984; Liu & Jenson, 2004). Studies using adult subjects show that feedback is especially important at the beginning of practice to stabilize the GMP, with specific knowledge of results being most helpful when errors are large (Lai, Shea, Wulf, & Wright, 2000; Shea & Wulf, 2002). With children, the optimal level of feedback changes with age. In a study using knowledge of results (children were told how well they did on the task after each practice trial) to determine the production of the next motor task response, 8- and 10-year-old children required more time to process the results and begin the next performance trial than did 14-year-old children or adults.

This finding indicates that the ability to evaluate and use knowledge of results improves with age (Barclay & Newell, 1980). As subjects became familiar with the task, the amount of information processing time decreased, showing that the effectiveness of feedback and knowledge is age dependent.

A recent study examined the effect of different types of feedback on the skill acquisition of 4 to 6-year-old children in a cycling task (Liu & Jensen, 2004). Children were asked to learn to cycle at 80 revolutions per minute. Three types of feedback were used: visual feedback of a computer monitor displaying current and target speeds, auditory feedback using different tones to indicate current and target speeds, and audio-visual feedback, a combination of both types of feedback. Results showed that visual feedback was more effective than auditory or auditory-visual feedback for retention and transfer. Visual feedback helped young children maintain the learned cycling speed and transfer that motor skill to a different cycling speed (Liu & Jenson, 2004).

In summary, children's motor ability changes with development. Children display more variability in their performance than do adults, but, with practice, they can begin to approximate the performance of adults (Deutsch & Newell, 2004). Children use different strategies than adults when performing motor tasks, relying more on feedback and knowledge of results to correct errors, rather than using an internal model to think about the needed movement and prevent errors (Thomas *et al.*, 2000).

Children benefit from a blocked practice schedule early in skill acquisition. Once a child has reached a base level of proficiency, a variable schedule is then effective for retention and transfer (Guadagnolli & Lee, 2004). More research is needed to determine how children learn motor skills as compared to adults and how practice schedules and feedback affect acquisition, especially in tasks using fine motor skills. Researchers may examine the role of motor skills in music learning to better understand the interaction between children's motor and musical development.

In a review of motor learning, Zdzinski (1991) suggests that principles of motor learning can be applied to music learning. Motor learning studies about types of practice provide implications for music educators, suggesting that practice should be varied and spaced across time. Instructional techniques such as feedback and modeling improve motor and music learning, with different types of feedback and modeling leading to different success levels among learners.

The process of reviewing literature on the motor development of children raises questions and issues for music learning research. Gardner (1973) suggests that

> A reasonably competent 7-year-old should understand the basic metrical properties of his musical system and the appropriate scales, harmonies, cadences, and groupings, even as he should be able, given some motifs, to combine them into a musical unit that is appropriate to his culture, but is not a complete copy of a work previously known. What is lacking is fluency in motor skills, which will allow accurate performance, experience with the code, tradition and style of that culture, and a range of feeling of life. (p. 197)

Proficient adult musicians generally start learning music as children, and music making involves the use of motor skills. However, much of the experimental research on motor skill learning has been developed with adult subjects. Studying the development of children's motor skills through music tasks may result in a greater understanding of music learning in general.

Development and training both contribute to children's music learning. The importance of development as compared to the importance of training in the context of music learning is still an issue. Educators are not always aware of developmentally appropriate teaching strategies to use in their classrooms (Miranda, 2004). Should we have young children practice specific motor skills during music instruction or will they naturally acquire the skills with time? What types of practice should we use? How can we encourage children to broaden their cognitive strategies and become more experimental and independent when practicing? Do music method books use developmentally appropriate strategies? What are the most effective teaching strategies for the development of motor skills?

THE USE OF MODELING IN INSTRUCTION

Modeling in Educational Theory

Research literature in musical development and instruction and motor learning identify modeling as an essential instructional technique for learning. The use of modeling as an instructional strategy has roots in early educational practices and theories. Pestalozzi, an influential educator in the early 1800's, promoted the ideas of child centered, experience-based teaching and active learning. In music teaching, he emphasized sound before sign, learning to sing or play before learning written notes or names, and learning by observation, listening, and imitation (Barlow, 1977). Other educators have also emphasized the importance of modeling in learning.

Bandura (1977), in his Social Learning Theory, stated that "most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action" (p. 22). Bandura believed that modeling gives the learner a conception of the way a skill is to be performed, creating a guide for action. The learner is given an accurate model, rather than designing a cognitive conception based only on trial and error. Because the amount of trial and error is lessened, modeling increases efficiency of skill learning (Bandura, 1986).

In his Social Learning Theory, Bandura defines learning through the development of mental models to guide behavior. The learner observes a model, internalizes the model, and then creates an individual mental model which guides behavior. Four main components comprise the social learning theory: attention, retention, production, and motivation. The first component involves giving attention to the model, which the teacher can prompt through the use of demonstrations, verbal instructions, and exaggerated motions. Following learner attention to the model, the model must be retained through imagery, mental practice, or rehearsal. After the model has been observed, remembered, and generated by the learner, the learner uses the mental model to produce the desired behavior. Feedback, evidence of progress, and eventual success at the skill provide the motivation for the learner to continue the cycle with a new behavior or cognitive skill.

Modeling in Motor Learning Research

Modeling is also a topic of research in the area of motor learning and has been defined as a cognitive process in which a learner attempts to reproduce an observed action or skill performed by another person (McCullagh, Weiss, & Ross, 1989). In many studies of motor learning, the term "modeling" refers to the observation and imitation of a visual model. The term "observational learning" can also be used to describe the process of visual modeling.

Certain studies compared and combined visual modeling with other instructional techniques to determine differences in learning. SooHoo, Takemoto, and McCullagh (2004) compared visual modeling with imagery in a free-weight squat lift task. Subjects (22 females) either watched a video model of a female accurately performing the squat lift task or listened to a female voice explaining how to perform the task while imagining how to complete the task themselves. Subjects in the model group performed significantly better on an acquisition test than subjects in the imagery group, and when given the choice between modeling or imagery, 14 subjects selected the model as their preferred instructional strategy.

Weeks and Anderson (2000) used three groups of subjects to investigate the effects of different combinations of practice with a visual model of an overhand volleyball serve. The Pre-practice Group watched ten pre-practice demonstrations and then practiced serving the volleyball. The Interspersed Group combined demonstration with practice throughout the acquisition phase: one demonstration, three practice attempts, one demonstration, three practice attempts. The Combination Group watched five demonstrations initially and then watched one demonstration after every three practice attempts. The researchers found that exposure to a visual model before practice and during earlier stages of practice was optimal for acquisition and retention of form in an overhand volleyball serve. Subjects' mean accuracy scores were unaffected by the different modeling schedules, indicating that the interaction between modeling and practice had little influence on outcome performance when outcome feedback was present on a trial by trial basis. However, in acquisition and retention, the Combination Group (five demonstrations and then demonstrations combined with practice attempts) obtained the highest scores, followed by the Pre-practice Group and the Interspersed Group. Based on these findings, the researchers suggest that visual modeling is optimal before practice and in the early stages of practice.

In a separate two-part study of observational learning, Shea, Wright, Wulf, and Whitacre (2000) found that observational practice (observation and imitation of a visual model) in combination with physical practice leads to more effective performance on a key press task. Subjects were divided into three groups: a physical practice group, an observation group, and a control group. Although subjects in the observation group performed better than subjects in the control group at task retention, the physical practice group performed best on the retention test. However, in a transfer task, the observation group performed as well as the physical practice group.

Shea *et al.* (2000) further explored the effects of physical practice combined with observation of a model in a secondary follow-up experiment, in which they compared the performance of subjects in a physical-practice-only group with subjects in a physical practice and observational learning (visual model) group. Results indicated that although no differences existed between groups for the retention task, the combination of physical practice with observational learning proved to be more effective for the transfer task.

These studies show visual modeling to be an effective instructional strategy. Subjects who received a visual model performed better than did subjects without a model (SooHoo *et al.*, 2004). Visual modeling seems to be most useful when it precedes practice and in the early stages of practice (Weeks & Anderson, 2000). Additionally, visual models are effective when combined with physical practice and the combination of visual modeling and physical practice leads to better task retention (Weeks & Anderson, 2000) and transfer (Shea *et al.*, 2000).

Models can also be auditory. A musical recording or a teacher demonstrating a musical passage, either by singing it or playing it on an instrument, is an example of auditory modeling in music. In motor learning, auditory modeling is frequently used in tasks involving timing sequences. In these tasks, the model consists of a sequence of tones matching the temporal characteristics of the target goal (Lai, Shea, Bruechert, & Little, 2002). A sequence could consist of tones of different length, for example, long, short, short, long, with the length of sound representing the desired length of key press in a tapping test.

Shea, Lai, and colleagues (2002, 2001, 2000) have found the use of auditory models to be effective in enhancing relative timing performance and learning. As discussed earlier, relative timing refers to the ability to accurately perform timings of key presses in relation to the entire sequence and it requires the use of the Generalized Motor Program. Absolute timing is the ability to perform timings specific to one task, and refers to the parameters of the task, the rules or specific requirements needed to carry out the task (Shea *et al*., 2001; Wulf and Shea, 2002; Shea *et al.*, 2000). In a study using three different modeling conditions (no model, model present 50% of the time, model present 100% of the time), Lai, Shea, Bruechert, and Little (2002) found that the 100% and 50% modeling conditions had positive effects on acquisition and retention in a key press task as compared to the no model group.

In a two-part experiment, Shea, Wulf, Park, and Gaunt (2001) studied the effect of an auditory model combined with physical or observational practice (visual model) on relative and absolute timing in a key press task. In the first experiment, subjects learned a sequence of five key presses on a computer keyboard. Subjects were divided into two groups, model and no model. Subjects who were given an auditory model had better relative and absolute timing performances than did subjects who did not hear the model.

A second experiment was designed to test the effect of an auditory model on relative and absolute timing when subjects physically practiced the sequence and when they simply observed someone else practicing the sequence. Subjects were again divided into model and no model groups, but were also divided into pairs. In each pair, one person physically practiced the key press sequence while the other observed the entire practice session. Results were similar to the first experiment. Relative timing was enhanced by the use of an auditory model for both the physical practice subject and the observer. Absolute timing was only enhanced for subjects in the model condition who physically practiced the sequence (Shea *et al*, 2001).

These studies demonstrate the effectiveness of an auditory model in learning. Subjects who hear an auditory model prior to practice perform better after practice. Of particular interest is the finding that observing a visual model while also hearing an auditory model enhances performance, even in the absence of physical practice (Shea *et al.*, 2001). This finding provides support for instruction that combines visual and auditory modeling with practice and exemplifies Bandura's Social Learning Theory. Subjects hear and see the model, retain it through practice, mentally re-create the model, and then demonstrate learning through performance. Thus, modeling is effective because it allows learners to have an accurate representation of their target goal and use that representation to guide their practice, identify errors, and self-correct. The practice strategy of trial and error becomes more efficient because learners can more effectively identify errors, using the model to guide their practice trials.

Modeling in Music Education Research

Auditory and visual modeling has implications not only for motor skill acquisition and learning theory, but also for music education. In a review of motor learning and its applications to music teaching, Zdzinski (1991) reviews findings on the effect of modeling on the motor skill development of learners of different ages. In a balance task with 7- and 9-year-old females, modeling was most effective for the 7-year-olds when presented before practice began. For the 9-year-old subjects, introduction of the model after practice began enhanced performance, but introduction of the model after practice interfered with the performance of the younger children (Thomas, Pierce, & Ridsdale, 1977 as cited in Zdzinski, 1991). Zdzinski suggests that these findings could apply to music teaching, with modeling prior to practice being the most effective modeling timing for younger children (Zdzinski, 1991).

Research on effective music teaching focuses on areas such as the pacing of teacher presentation and student response opportunities, teacher-student interactions, and specific teacher behavior, including feedback and modeling. Effective teaching is evidenced by less teacher talk and a combination of frequent, brief student performance episodes with teacher feedback and modeling (Duke & Simmons, 2004).

Modeling in music instruction has been defined as the live or recorded presentation of anything that may be later imitated by an observer (Madsen, Greer, and Madsen, 1975). In music lessons or rehearsals, modeling consists of alternations of teacher demonstrations and student imitations, with teachers using their instrument, voice, or electronic media and students responding with their instrument or voice (Dickey, 1992). Modeling generally uses minimal verbal direction.

Sang (1987) proposed that effective modeling requires the following sequence of events: the teacher must be able to demonstrate basic musical performance behaviors such as tone quality and articulation; the teacher must demonstrate more subtle aspects of music performance, such as phrasing or vibrato; the teacher must demonstrate a variety of musically related performance behaviors (posture, playing position, embouchure); the teacher must be able to demonstrate a wide variety of brief melodic and rhythmic sequences by ear, imitating incorrect student performances and providing musically correct examples.

Teacher feedback and modeling are important to document in teaching. In studies of Suzuki teaching, Duke (1999) found that teacher performance (modeling) accounted for 27% of lesson time and teacher approximations (forms of modeling such as clapping, singing, counting, conducting) accounted for 9% of lesson time. Colprit (2000) analyzed lessons taught by 12 expert Suzuki string teachers and found that 20% of all rehearsal frame time (lesson segments with specific targets) was devoted to teacher modeling, with teacher modeling occurring at a rate of 2.21 models per minute and teacher approximations at a rate of .55 approximations per minute. Speer (1994) and Kostka (1984) both found that more time in piano lessons was spent on teacher verbalization than on teacher modeling. In contrast, however, Siebnaler (1997) found that shorter teaching episodes, less teacher talk, and faster pacing with frequent directives, specific feedback, modeling, and strategies for improvement was associated with more effective teaching in private piano lessons (1997).

Modeling in Music Instruction

Modeling has been found to be effective for student learning while also being an efficient use of class time. In a study of four middle school band classes, Dickey (1991) compared verbal instruction to modeling instruction. Over a 10-week period, two classes were taught with verbal instruction (instruction in which the teacher used verbal directions, explanations, and imagery) and two with modeling instruction (teacher modeling and student imitation with minimal verbalizations). All subjects were given pre-and post-tests of ear-to-hand skills (replicating a three or four note musical model on their own instruments), kinesthetic response skills (imitation of a rhythmic pattern on a woodblock), and music discrimination skills (identifying differences between two musical models). The two classes with modeling instruction were significantly better at ear-to-hand skills and kinesthetic response skills on the post-test. No difference was found between the model and the no model group in general music discrimination. Using modeling as a teaching strategy also decreased dependence on unnecessary verbal communication. Dickey found that the average amount of class time spent in verbal communication was 36.6% in the verbal group, while only 21.8% in the model group (1991).

Different types of modeling have been shown to affect student performance. In a study with 44 college brass and woodwind majors, Rosenthal (1984) created four groups: a guided model group combining a verbal description with an aural model, an aural model group, a verbal group (verbal explanation only), and a practice group (no model). She found differences among the model conditions, with the aural model being most effective for improving notes, rhythms, and dynamics. No significant differences were found among the groups in their interpretation of musical phrasing. Verbal explanations alone were not as effective as the aural model alone. The combination of a verbal description with an aural model was significantly better than either the verbal model or no model at all. Rosenthal concluded that aural modeling was most effective for student performance and that if words were used, they needed to be in conjunction with an aural model.

Teaching that incorporates modeling is regarded as more effective than teaching that incorporates more verbal explanation. Indeed, there is a positive relationship between music teacher modeling and student performance (Dickey, 1992), coinciding with findings in motor research linking modeling with better performance and transfer (Lai *et al.*, 2002; SooHoo *et al.*, 2004). Both Rosenthal and Dickey's research highlight the importance of an aural model over verbal explanations in music learning, and SooHoo and colleagues' motor research demonstrates greater learning with a visual model than with verbal guided imagery (2004). Frequent occurrences of appropriate modeling are associated with better performance in motor skill tasks (volleyball serve, Weeks & Anderson, 2000) and music tasks (improvement in ear-to-hand and kinesthetic response skills, Dickey, 1991; Dickey, 1992). Additionally, "teachers who have strong modeling skills and apply those skills in teaching are more likely to produce better performing students than teachers who do not" (Sang, 1987, p. 158).

Recent research on modeling in music instruction has focused on types of aural modeling and modeling in combination with other techniques. Hewitt (2005) focused on the effects of timbre and register characteristics of instrumental models on the music performance achievement of middle school instrumentalists. In his study, students were divided into model and no model conditions. The model condition listened to a recording of the piece with counterbalanced combinations of same and different register and timbre (i.e., same timbre, same register; same timbre, different register; different timbre, same register; different timbre, different register). No significant differences were found between conditions or design.

In a previous study, Hewitt (2001) focused on the effects of modeling, self-evaluation, and self-listening on junior high instrumentalists' music performance and practice attitude. Using 82 woodwind, brass, and percussion students, he found that subjects who listened to a recorded model during self-evaluation (self ratings of tone, intonation, technique, articulation, melodic and rhythmic accuracy, tempo, and interpretation on a 5-point scale) improved more in areas of tone, melodic accuracy, rhythmic accuracy, interpretation, and overall performance than did those not listening to a model. No improvement was found in intonation, technique, articulation, or tempo. When students were not given the opportunity to evaluate their own performance, no differences were found in performance scores between the model or no model groups. Results of this more recent study indicate the value of an aural model for music performance, supporting the earlier findings of Dickey (1991, 1992), Rosenthal (1984), and Sang (1987).

Modeling has also been found to be an effective instructional technique when teaching vocal music. In a study looking at the effects of verbal instruction, vocal modeling, kinesthetic exploration (movement, acting, speaking) and audio-visual instruction (use of a power point presentation) on singing expressiveness of middle school students, subjects in the vocal modeling group received higher mean scores than did subjects in other conditions. Subjects in the verbal instruction group received significantly lower scores than subjects in all other treatment conditions (Ebie, 2004), again supporting findings in instrumental music indicating the effectiveness of an aural model as compared to teacher verbalizations (Dickey, 1991; Rosenthal, 1984; Rosenthal *et al.*, 1988; Henley, 2001).

Taylor (2006) examined teaching effectiveness in an elementary music setting, assessing rehearsal strategies of recognized Orff Schulwerk teachers using student achievement as a dependent measure. He found that students were most successful when teachers utilized clear, explicit directives and positive modeling. Teacher modeling was one of the most effective behaviors preceding student performance improvement.

Klinger, Campbell, and Goolsby (1998) compared modeling of an entire song (immersion) to phrase-by-phrase modeling of the same song with second graders. They found that second graders who learned the entire song through immersion performed the song with fewer errors than did children who learned the song one phrase at a time. This research suggests that presentation of an entire model is more effective for learning than gradual presentation of individual parts to comprise a meaningful whole (Klinger *et al.*, 1998).

Several general conclusions can be made about the use of modeling in music education. The use of modeling in class seems to decrease the overall amount of teacher talk. Research in teacher effectiveness indicates that greater teacher effectiveness is achieved when verbalizations contain specific information or directive statements and extraneous talking is minimized (Dickey, 1991; Dickey, 1992; Rosenthal, 1984; Siebnaler, 1997; Duke, 1999). A positive relationship exists between teacher modeling and student performance, with students learning to make complex discriminations through the use of aural models. Modeling is effective with all ages, elementary students (Baker, 1980; Taylor, 2006), middle school students (Dickey, 1991; Ebie, 2004; Hewitt, 2001), high school students (Henley, 2001) and college students (Rosenthal, 1984; Rosenthal *et al*., 1988). Various types of models (taped, live, modeling of poor technique or sound quality, modeling of excellent technique or sound quality) are effective (Dickey, 1992). Aural modeling of a musical passage is generally a more effective teaching technique than simply giving verbal directions (Ebie, 2004; Rosenthal, 1984; Rosenthal *et al.*, 1988; Sang, 1987) and teachers who can perform effectively on an instrument or with their voice model more frequently than teachers who have weaker performance abilities (Sang, 1987). Finally, teachers must have the skill to demonstrate one performance variable correctly or incorrectly while still maintaining consistency within the performance of other variables (Dickey, 1992).

An analysis of teacher-student interactions in piano lessons supports the value of modeling as an instructional strategy (Siebnaler, 1997). Siebnaler videotaped 13 piano teachers during three consecutive lessons with one adult and one child student. Segments of 8-12 minutes were excerpted and teacher behavior, student behavior, and lesson progress were analyzed. Ten excerpts were then evaluated by five expert piano pedagogues who rated teaching effectiveness.

Results showed that active teachers were ranked higher by observers, provided more modeling and gave more feedback than did inactive teachers. Student performance episodes were shorter in more active teaching and were performed more successfully, also suggesting that longer student performance times indicated struggling performance without appropriate teacher intervention. Duration and pacing of teacher behavior were important in discriminating instructional quality: shorter episodes and faster pacing with frequent directives, specific feedback, modeling, and strategies for improvement were associated with more effective teaching (Siebnaler, 1997).

In a comparison of teaching behaviors of piano teachers in the United States and China, Benson and Fung (2005) found similarities and differences in the use of modeling. Teachers in both countries used teacher modeling and teacher modeling with the student playing. However, Chinese teachers had significantly more multiple modeling episodes (singing, playing, or gesturing simultaneously) than American teachers. Despite differences in teacher behavior, however, no differences were found in student performance. In other studies, Speer (1994) and Kostka (1984) both found that more time was spent on teacher verbalization during piano lessons than on teacher modeling.

These findings coincide with research on modeling in classroom music instruction. Effective teachers use modeling to demonstrate musical ideas and nuances instead of relying on verbal explanations. Less experienced or ineffective teachers spend more time on lengthy verbal explanations, instead of providing students with specific directives, modeling, and repetition until each target goal is achieved.

CONCLUSIONS

Researchers in music education and motor learning have demonstrated the effectiveness of modeling as an instructional technique. Zdzinski concluded that principles of motor learning could be applied to music learning. Specifically, he focused on the effect of modeling on children of different ages. Although research in music education has shown modeling to be effective across ages (e.g., Dickey, 1992), research in fine motor skills indicates modeling to be more effective for younger students when used prior to task presentation, while presentation later in the learning process was more effective for older students (Zdzinski, 1991).

Music making requires the use of fine and gross motor skills. To understand children's music learning more deeply, we must be aware of how children learn motor tasks and what affects their motor performance in music tasks. Research shows that children's internal representations for non-musical motor tasks are not as reliable as those of adults and that children generally use a feedback-based improvement strategy rather than a feedforward strategy (Lazarus *et al.*, 1995; Thomas *et al.*, 2000). In other words, children are being reactive instead of proactive, basing motor movement on visual knowledge of results instead of formulating a movement plan based on an internal model. Would children use a feedback-based strategy for a musical motor task, where they also receive auditory feedback? Would auditory feedback help develop a musical schema that would in turn facilitate the development of a specific motor skill? Would there be a difference in motor skill learning with or without auditory feedback? How would the performance accuracy of children of different ages differ from each other in motor tasks with auditory feedback? How would the use of a model affect children's motor and music learning? Would familiarity with a melody enable children to use a feedforward learning strategy? Would modeling strengthen children's internal representation for the skill to be performed or make the internal representation more reliable?

Many questions can be raised about children's motor development in relation to the performance of an instrument. This study will investigate the effects of modeling on children's performance of a simple piano melody, in order to deepen our understanding of how children learn to play an instrument and provide instrumental music teachers with effective teaching strategies.

Chapter 3: Methodology

The purpose of this study was to examine how children's ability to play a simple keyboard melody is affected by grade and familiarity with the melody. The study was designed to answer the following questions: Does familiarity with a musical model (recording) improve children's note sequence accuracy when performing a simple piano melody after one training session? What differences in note sequence accuracy exist in children of different ages when performing a simple melody after one training session? How does varied auditory feedback (i.e., the presence of sound, lack of sound, or transposed sound) affect note sequence accuracy in the performance of a newly learned melody?

PILOT STUDIES

Two pilot studies were conducted to inform decisions about the music to be presented, teaching strategy, testing materials, and testing procedures. One pilot study was conducted to test the appropriateness of the chosen melody for the study. The melody needed to be simple enough to be taught to children in one session and unfamiliar to children. The first 16 notes of *Perpetual Motion*, an accepted pedagogical piece familiar to music educators and composed by Suzuki, was selected (Figure 1).

Figure 1: The first two measures of *Perpetual Motion* from *Suzuki Violin Book One*, presented in the original form and then written as four measures of quarter notes in the key of C major.

The present study was based on the assumption that children who hear an aural model repeatedly become familiar with the model. Finding a way to determine that this assumption is indeed true was another purpose of the first pilot study. A perceptual test based on the melody was developed to assess whether children already familiar with the test melody would be able to identify pitch errors in the piece. Twenty children from The University of Texas String Project participated in this pilot study. They were all familiar with the piece *Perpetual Motion*, having already played it in *Book One*. All children were already playing *Suzuki Book Two or Three* on the violin, viola, or cello, and were in the same music skills class.

Children listened to a piano recording of the test melody and tapped claves whenever they heard a pitch error. The recording contained six errors: two out-of-key errors (most obvious errors, errors 1 and 4 in Figure 2), two within-key errors using an ascending 4th, a larger interval than typical for the piece (less obvious errors, errors 2 and 5 in Figure 2), and two sequential mistakes which sounded tonally accurate (least obvious errors, errors 3 and 6 in Figure 2). Participants were asked to tap claves when they heard "something unexpected, something surprising, or something weird." Error identification was immediate, with all children tapping within two beats of the pitch error and displaying recognition through changing facial expressions. Because children who were familiar with the melody immediately recognized errors (19 out of 20 children identified all six errors within two beats), a second pilot study was needed to test the error identification of children unfamiliar with the melody. It was expected that children unfamiliar with the melody would not recognize as many of the errors as did those who were familiar with the piece.

Figure 2: The test melody repeated four times with six errors.

The purpose of the second pilot study (n = 10, 5 familiar with the melody, 5 unfamiliar with the melody) was twofold. First, I wanted to see how children who were not familiar with the test melody reacted to pitch errors. These children (n = 5) either did not tap at all or identified the two most obvious errors in the piece by tapping within three beats of the error. The children who were familiar with the melody (because of exposure through string lessons) reacted in the same way as children in the first pilot study, correctly identifying all six errors by tapping within two beats of the error and displaying recognition through a change in facial expression. Because of the immediate identification abilities of children who were familiar with the melody and the slower or non-existent reactions of children unfamiliar with the melody, correct error identification was defined as a tap that occurred within three beats of the error.

The second purpose of this pilot study was to teach all ten children to play the test melody on the piano, to determine if performance differences existed between children who were and were not familiar with the melody, and to refine the teaching methodology. In the pilot study, children who were familiar with the melody prior to piano training played more correct notes than did children who were not familiar with the melody. Decisions about the methodology and procedures were based on the reactions and performance of the children in this pilot study and will be explained throughout the chapter.

SAMPLE

This study was conducted at an elementary school in central Texas. The school had an enrollment of 370 students, averaging 20 students per class, and was consistently rated "exemplary" by the Texas Education Agency. It was part of a school district that serves a constituency of highly educated professionals and actively involved parents. In this school district, approximately 88% of students were Caucasian, 5.1% Hispanic, 6.3% Asian/Pacific Islander, 0.4% African American, and 0.2% Native American.

At this elementary school, students received music instruction every three days. For the younger grades, the curriculum focused on singing, music listening, movement, and rhythm, and introduced Orff instruments and recorders. For the older grades, emphasis was also placed on singing and listening, with further instruction on Orff instruments and recorders. No piano instruction was given during music class.

After obtaining consent from the music teacher and school principal, a letter describing the project was distributed to the parents of all kindergarten through fourth grade students at the school (see Appendix A for complete letter). This letter outlined the purpose of the research project, identified the researcher, supporting professor, and collaboration with the school music teacher, and described what children would be asked to do if they participated in the project. Parents were asked about their children's musical background. Questions included: Does your child take private music lessons? What instrument do they play? How long have they taken lessons? Parents were also asked about the musical background of the family. Questions included: Does anyone in your family take private music lessons? What instrument do they play? How long have they taken lessons? Do you have a piano at home?

Based on parents' responses, children who had taken more than four piano lessons were excluded from the sample. Additionally, children who had taken string music lessons or who had siblings currently taking string music lessons were excluded because of possible familiarity with the test melody. Two groups of children (N = 97, 39 female) participated in the study. Children from kindergarten to fourth grade were included, with ages ranging from 5 to 10 years old. Numbers in each grade were: K = 21, 1st = 19, 2nd= 20, 3rd= 17, 4th = 20.

In accordance with the University Institutional Review Board guidelines, parents returned consent forms allowing their children to participate in the study. Additionally, participants over the age of six signed an assent form indicating their awareness of the project and willingness to participate (see Appendix B and C for consent form/questionnaire and assent form, respectively).

RANDOMIZATION OF GROUPS

At this elementary school, there were three classes or groups of students per grade level (A, B, and C). At each grade level, children who had returned a signed consent form were randomly selected (with some restrictions of sex and age) from the three classes to comprise two groups: the experimental group (referred to as the "familiar group") and the control group ("unfamiliar group"). The selection was not completely random because of the need to take into consideration the sex and age of the children to allow for a similar number of boys and girls and a similar mean age in the two groups. The familiar and unfamiliar groups comprised the following numbers of boys and girls:

Table 1: Number of Participants per Grade in Each Group.

Grade	Familiar Group		Unfamiliar Group	
	Boys	Girls	Boys	Girls
Kindergarten	7	3	8	3
First	4	6	5	4
Second	5	5	5	5
Third	6	2	5	4
Fourth	7	3	6	4

MUSICAL MATERIALS

Selected Melody

Based on findings from the pilot study, the first 16 notes of the piece *Perpetual Motion* from *Suzuki Violin Book One* was selected as the melody children would learn to play. This piece was chosen for several musical reasons. The melody has been used for teaching string instruments to young children for decades. It stays within a pentascale, making it possible for participants to play on a keyboard without changing their hand position. In other words, five consecutive notes are used, allowing children to place each finger on adjacent keys and play the entire melody without moving their hand. The piece uses a combination of seconds and thirds, with no interval larger than a third. Measures three and four are more difficult than measures one and two, providing more of a challenge later in the learning process. *Perpetual Motion* is an accepted pedagogical piece familiar to music educators. However, based on the pilot study, the melody was unfamiliar to children not involved in string music lessons.

Recording

The first two measures of *Perpetual Motion* (two measures of eighth notes) were transformed into four measures of quarter notes and transposed to the key of C major (see Figure 1, p. 50). For the entire study, the test melody was modeled and taught as shown in Figure 1. For the recording, the four measures were played on the piano and looped 16 times, with the final repetition ending on the tonic chord. Based on the pilot study, a tempo of 92 = quarter note was used, with a simple tonic and dominant accompaniment. The total duration of the recording was 4 minutes, 14 seconds.

DESIGN

All testing and instruction was organized in the following way (Table 2). During the first two weeks, all children in the unfamiliar group were trained and tested. After children in the unfamiliar group had been tested, the recording was presented to all children at the beginning and end of music class for four class sessions. After the recording had been played in four class sessions, training and testing of the familiar group began. Both groups were trained and tested in the same way.

Table 2: Overall Experiment Design.

		Time Frame
Step 1	Training of Unfamiliar Group Error Recognition Test Performance Test 1[a] Playing 2 Measures Performance Test 2 Playing 2 Measures, No Sound Performance Test 1[b] Playing 2 Measures Performance Test 3 Playing 2 Measures, Transposed Sound Performance Test 4 Playing 4 Measures Error Recognition Test Tests 5 & 6 Memory Tests	Single Session
Step 2	Model presented to all children (Familiarization)	4 Sessions
Step 3	Training of Familiar Group (same as Step 1)	Single Session

FAMILIARIZATION PROCEDURES

The unfamiliar group was tested before the familiarization process began. Then, the familiar group listened to the piano recording of the test melody at the beginning and end of music class for four class periods before being tested. The music teacher directed attention to the piece at the beginning of the first class in which the recording was played by asking students to listen carefully. Following the first class, students listened to the recording as they quietly entered and exited the music room.

Attendance records were checked to determine if students in the familiar group were actually present in music class when the model was played. All students were present on the days in which they had music class, and all heard the recording eight times.

TRAINING AND TESTING SESSION

I worked individually with each subject in a small room attached to the music classroom during regular music class. All data were recorded using an Edirol MIDI keyboard controller and MaxRunTime software written for this experiment. All training and test sessions were videotaped and lasted approximately 25 minutes per subject. At the beginning of the training session, participants listened to the recording of the test melody and were asked if they recognized the song. Questions included: Do you recognize this song? Where did you hear this song? When did you hear this song?

Error Recognition Test

All participants then listened to a recording of the test melody with errors (Figure 3). The recording contained six errors: two out-of-key errors (most obvious errors, errors 1 and 4 in Figure 3), two within-key errors using an ascending 4th, a larger interval than typical for the piece (less obvious errors, errors 2 and 5 in Figure 3), and two sequential mistakes which sounded tonally accurate (least obvious errors, errors 3 and 6 in Figure 3). Participants were asked to tap claves when they heard "something unexpected, something surprising, or something weird."

Correct taps were defined as those occurring within three beats of an error. Any other taps that occurred were considered extraneous. These definitions were based on previous research in children's perception of musical changes and on the error recognition of children in the pilot test.

Figure 3: The test melody with six errors.

Learning and Practicing the Test Melody

Following the Perceptual Error Recognition Test, I taught individual students how to play the test melody on the piano in C major using the right hand. All teaching was done by rote; music notation was not used. Finger numbers were used as a teaching strategy. Finger numbers are used in standard piano teaching beginning method books (Alfred *Premier Prep Course*, Faber and Faber *Piano Adventures*, Hal Leonard *Standard Piano Library*) and are presented as the first strategy for note learning. Beginning pieces in these books use either numbers alone or numbers in conjunction with off-staff notes to help children identify which note to play by indicating which finger to press on the key. Because finger numbers are commonly used in teaching beginning piano students and because participants in the second pilot study had great difficulty learning the melody when finger numbers were not used, I decided to teach finger numbers and sing finger numbers with each model that I provided.

First, I explained right hand finger numbers (using the thumb as finger one) and asked the participants to move their fingers in the air according to finger number. Second, I placed the participants' fingers on the keyboard, positioning the thumb on a sticker on middle C and each finger in sequential order on D, E, F, and G. I asked participants to press each finger down one at a time to play a C major pentascale. Once the child played the pentascale, I asked him or her to repeat it one more time to practice moving the fingers.

Next, I began teaching the test melody, one measure at a time. I sang finger numbers with every demonstration (see Figure 4 for the test melody with finger numbers). I asked the child to listen and watch carefully, paying attention to "which one repeats." I played the first measure while singing the finger numbers and asked the child "which one repeats?" to help him or her focus on my demonstration. After the child answered the question I asked him or her to play what I just played. I then followed the protocol established by the pilot study: Researcher Model, Child Repeat, Model, Repeat, Model, Repeat. After three models and participant attempts, the within session test began: Model, Repeat, Repeat. I told children I would play the model one more time and that I wanted them to play it two times back to me. This test served to check learning throughout the practice session.

If the child did not follow the model and started on the incorrect finger, I asked the child to "pay attention to my starting finger." If the second try was incorrect, I touched the correct starting finger before the next trial. No other touching or singing occurred while the child was playing.

Figure 4: The test melody with finger numbers.

The same modeling and performance trial protocol was followed with measure two: three researcher models, three participant trials, and within session testing of Researcher Model, Child Repeat, Child Repeat. After measures one and two were taught individually, the two measures were combined into one unit (measures one and two), with five researcher models and five participant trials: Researcher Model, Child Repeat, Model, Repeat, Model, Repeat, Model, Repeat, Model, Repeat. The same process was followed for measure three, measure four, and measures three and four combined.

This teaching strategy is based on a stable practice schedule. Research has indicated that variable practice is generally better for adult motor task retention and transfer, and stable practice is thought to be better for novice participants when initially learning a skill (see review of literature section "Development of Motor Skills in Children: Practice" for more detailed information). For this study, I was interested in children's immediate improvement in note accuracy when playing the test melody. I expected that a stable practice schedule would allow the children to learn the melody in one training and testing session. A stable practice schedule, such as the one used, was considered to be most appropriate for beginning children for skill retention and achievement of a base level of proficiency (Guadagnolli, Holcomb, & Weber, 2004; Guadagnolli & Lee, 1999; McGill & Hall, 1990). Figure 5 provides a visual depiction of the teaching process.

Teach Measure 1

(Researcher Model, Child Repeat; Model, Repeat; Model, Repeat; Test: Model, Repeat, Repeat)

Teach Measure 2 (same protocol as Measure 1)

Teach Measures 1 and 2 together

(Researcher Model, Child Repeat; Model, Repeat; Model, Repeat; Model, Repeat; Model, Repeat; Test: Model, Repeat, Repeat)

Teach Measure 3

Teach Measure 4

Teach Measures 3 and 4 together

Figure 5: Teaching process during the training session.

This teaching process of either three or five researcher models and subject repetitions was established by the second pilot study. Initially, a subject-directed protocol was desired, meaning that the number of repetitions would be determined by the accuracy of participants' playing. Using this protocol, repetitions would end when the child played two correct trials. However, participants in the second pilot study displayed frustration and were not successful when playing measures one and two together. Because of child frustration and the large numbers of repetitions needed for younger children to learn the combined measures, a fixed number of repetitions was decided upon. Since most participants were able to learn the one measure sections within three repetitions, it was decided to provide three models and performance trials before beginning the within session test. Participants had more difficulty with the combined two measure sections. After trying various numbers of repetitions, five repetitions was determined to be the optimal number of repetitions to maximize learning and avoid frustration because it allowed a certain number of children to complete the task. The protocol was deemed adequate to elicit responses that would have the degree of variability necessary for the study.

The test melody was modeled with the quarter note played at 92 beats per minute. This tempo was established according to the results of the pilot study. However, if a child could not play at this tempo, the researcher modeled with the child's chosen tempo (the tempo of the first performance attempt), but no slower than quarter note at 76 beats per minute.

Testing

Immediately after teaching and practicing the test melody as described above, tests were administered to identify pitch sequence accuracy when playing the first two measures, pitch sequence accuracy when playing all four measures, and pitch sequence accuracy when playing the first two measures with transposed sound feedback.

*Test 1^a^*: The subject listened to one model of the first two measures of the test melody played by the researcher. The subject played the first two measures of the test melody two times.

Test 2: No Sound Test: The subject played the first two measures of the test melody two times without hearing the sound (the sound was muted on the computer; MIDI data were recorded). Participants were asked if it was harder or easier to play without the sound and why.

*Test 1^b^*: Repetition of Test 1. The researcher again modeled the first two measures and the subject played two performance trials. The purpose of administering this test was to see if performances changed during testing or if participants continued to repeat an incorrectly learned sequence.

Test 3: Transposition test: The subject played the first two measures of the test melody two times at the same tempo starting on B instead of Middle C. The same finger sequence was played. No model was given. The researcher asked the participants if anything was different in this test. Questions included: Does this sound the same or different to you? Can you tell me why it sounds different? Which version do you like better?

Test 4: The participants played all four measures of the test melody. The researcher modeled all four measures first and then participants played two performance trials.

Repetition of Perceptual Error Recognition Test: Participants listened to the test melody recording with errors for a second time and were asked to identify notes that were "surprising, weird, or unexpected" by tapping the claves together.

Memory Tests

On a subsequent day, participants were administered two subtests of the Kaufman Assessment Battery for Children, the Number Recall subtest and Hand Movement subtest. These tests were used to assess motor and number memory ability. For the Hand Movement test, I tapped my hand on a table in one of three positions: fist, side of hand, or palm of hand. The positions were combined into sequences, starting with two positions and gradually adding more combinations and repetitions. I asked the subject to watch while I modeled each sequence and then the subject repeated the sequence. An example of a hand motion sequence is fist, side of hand, fist, palm.

The Number Recall test sought to determine how well children remember a series of numbers. I read a sequence of numbers, one per second, and the child repeated the sequence. The test used only one syllable numbers (e.g., one, eight, ten), beginning with three numbers and gradually adding more. Because of the standardization of these tests, all participants were administered the same test, regardless of age, with different specifications for where to begin and end the test for participants of different ages.

Chapter 4: Results

Tests were administered to determine differences in note accuracy between children who were familiar with the test melody and children who were not familiar with this melody. After the training session, in which the researcher taught all children to play the test melody by rote, seven tests were administered, recorded in a MIDI sequencer, and videotaped. The two standardized memory tests, the Hand Movement test and Number Recall test were scored following the procedures described in the test manual. For the keyboard performances tests, however, in which participants played either two measures or four measures of the test melody, scoring procedures needed to be determined.

SCORING PROCEDURES: PERFORMANCE ACCURACY

Measurements focused on note accuracy, with the term "note" referring to a key as a pitch rather than a rhythmic value. Rhythmic accuracy or temporal relationships were not considered. Sequences of notes were analyzed for accuracy. Determining if a note or sequence of notes was correct or incorrect was difficult because of the many extra notes, repeated notes, and missed notes played by the children. Two dependent measures of children's performance were used: number of correct measures played and number of correct notes played.

Correct Measures

Children remember note sequences and perceive structure differently than adults (Palmer, 2005). Because children tend to make pitch-ordering errors in sequences longer than three or four pitches (Drake & Palmer, 2000), the unit of one measure containing four pitches was determined to be an appropriate sequential unit for children.

Additionally, each measure was taught as one unit before the next measure was added, making it a logical testing unit.

A correct measure was defined as a measure in which all four pitches were played in the correct order. In the four-measure sequence participants practiced, each measure was labeled as either correct or incorrect. Standardized tests for children often measure responses as completely correct or completely incorrect, with one partial mistake rendering a complete response as incorrect (example: Kaufman Assessment Battery for Children). Defining a correct measure as a measure containing four correct pitches in the correct order seemed appropriate for this test.

The total possible score for the four-measure sequence was 4. Analyses were based on MIDI data and corroborated with video data. In the following examples, the written numbers refer to both scale degrees (1 being the tonic) and finger numbers (1 being the thumb of the right hand).

Measure 1: 1 2 3 3 (C D E E)

Measure 2: 2 3 4 4 (D E F F)

Measure 3: 3 4 5 3 (E F G E)

Measure 4: 4 2 5 5 (F D G G)

All four notes in a measure had to be played in the correct order for the measure to be considered correct.

An example of the scoring procedure for number of correct measures follows. A second grade subject in the familiar group played this sequence. Incorrect notes are identified in bold with superscript numbers referring to text explanations.

Subject Played: 1 2 3 3 2 3 4 4 3 4 5 **5**[1] **2**[2] **3**[3] **2**[4] **4**[5] 5 5

Correct Sequence: 1 2 3 3 2 3 4 4 3 4 5 3 4 2 5 5

Sequences were grouped in the most beneficial way for the child, that is, the grouping that produced the highest score. This sequence was then grouped as follows:

Subject Played:	1 2 3 3	2 3 4 4	3 4 5 **5**[1]	**2**[2] **3**[3]	**2**[4] **4**[5] 5 5
Correct Sequence:	1 2 3 3	2 3 4 4	3 4 5 3		4 2 5 5

On the keyboard, this sequence is:

C D E E   D E F F   E F G **G**[1]   **D**[2] **E**[3]   **D**[4] **F**[5] G G

This performance trial has 2 correct measures (Measure 1, Measure 2). Error number 1 is an incorrect note repetition, rendering the entire measure incorrect. Errors number 2 and 3 are additional notes that do not belong in the sequence and therefore considered incorrect. Errors 4 and 5 are a reversal of what the sequence should be and render the entire measure incorrect.

Another example follows. A third grade male subject played:

Subject Played: **1**[1] **2**[2] 1 2 3 3 **3**[3] **2**[4] **4**[5] **3**[6] **3**[7] 5 5

Correct Sequence: 1 2 3 3 2 3 4 4 3 4 5 3 4 2 5 5

This sequence was grouped as:

1[1] **2**[2]   1 2 3 3   **3**[3] **2**[4] **4**[5] **3**[6] **3**[7]   5 5

This performance trial has 1 correct measure. Note errors 1 and 2 are incorrect because they are not part of a complete measure. Note error 3 is an incorrect repetition and does not belong in the measure. Note errors 4, 5, 6, and 7 are incorrect in pitch and order and do not create a complete measure. The final measure is missing the first two pitches.

Correct Notes

A second dependent measure of children's ability to perform successive pitches was number of correct notes. A correct note was defined as either preceding or following another correct note. This definition helped ensure that correct pitches were occurring because of subject awareness of the melodic sequence and not simply because of chance. False starts were not counted in the total score. The following examples show the scoring procedures for correct notes.

Subject Played:	1 2 3 3 2 3 4 4 3 4 5 $\mathbf{5}^{1}$ $\mathbf{2}^{2}$ $\mathbf{3}^{3}$ $\mathbf{2}^{4}$ $\mathbf{4}^{5}$ 5 5
Correct Sequence:	1 2 3 3 2 3 4 4 3 4 5 3 4 2 5 5

This sequence was grouped as:

Subject Played:	1 2 3 3	2 3 4 4	3 4 5 $\mathbf{5}^{1}$	$\mathbf{2}^{2}$ $\mathbf{3}^{3}$	$\mathbf{2}^{4}$ $\mathbf{4}^{5}$ 5 5
Correct Sequence:	1 2 3 3	2 3 4 4	3 4 5 3		4 2 5 5

On the keyboard, this sequence is:

C D E E D E F F E F G $\mathbf{G}^{1}$ $\mathbf{D}^{2}$ $\mathbf{E}^{3}$ $\mathbf{D}^{4}$ $\mathbf{F}^{5}$ G G

This sequence has 13 correct pitches (1, 2, 3, 3, 2, 3, 4, 4, 3, 4, 5, 5, 5). Note error 1 is an incorrect repetition. Note errors 2 and 3 are not preceded or followed by accurate notes. Note errors 4 and 5 are a reversal of the correct sequence and therefore are not preceded or followed by accurate notes.

Another example of correct notes follows. A third grade male subject played:

Subject Played:	$\mathbf{1}^{1}$ $\mathbf{2}^{2}$ 1 2 3 3 $\mathbf{3}^{3}$ $\mathbf{2}^{4}$ $\mathbf{4}^{5}$ $\mathbf{3}^{6}$ $\mathbf{3}^{7}$ 5 5
Correct Sequence:	1 2 3 3 2 3 4 4 3 4 5 3 4 2 5 5

This sequence was grouped as:

$\mathbf{1}^{1}$ $\mathbf{2}^{2}$ 1 2 3 3 $\mathbf{3}^{3}$ $\mathbf{2}^{4}$ $\mathbf{4}^{5}$ $\mathbf{3}^{6}$ $\mathbf{3}^{7}$ 5 5

This sequence has 6 correct pitches (1, 2, 3, 3, 5, 5). Note errors 1 and 2 are incorrect because they are part of a false start. The subject played the first four notes correctly after the false start. Note error 3 is an incorrect repetition of E, the third scale degree. Note errors 4 through 7 are incorrect because they are not preceded or followed by a correct note.

Number of correct notes and correct measures were determined for each subject's best performance of the entire four-measure sequence. For most participants, the first performance directly following the model was more accurate than their second performance trial. However, if the child played more correct notes or measures during a second attempt at the sequence, the second performance was used for data analysis.

SCORING PROCEDURES: ERROR RECOGNITION TEST

At the beginning and end of the practice session, participants listened to a piano recording of the test melody without accompaniment. The recording played at a tempo of 92 = quarter note and contained six errors: two out-of-key errors (most obvious errors), two within-key errors using an ascending 4th, a larger interval than typical for the piece (less obvious errors), and two sequential mistakes which sounded tonally accurate (least obvious errors). Participants were asked to tap claves when they heard "something unexpected, something surprising, or something weird."

Previous research on children's music perception and development used clapping to show perception of a change in sound. Children clapped when they heard changes in register, timbre, or harmony (Costa-Giomi, 2003; Costa-Giomi & Descombes, 1996; Costa-Giomi and dos Santos, 2001; Costa-Giomi, 1994a; 1994b; Flowers & Costa-Giomi, 1991). For this study, taps were performed on claves and were classified as correct or extraneous. Based on previous research and children's immediate error identification during the pilot study, correct taps were defined as taps that occurred within three beats of an error and extraneous taps as all others. The maximum possible score was 6.

The numbers of taps were counted for the pre-test and the post-test of the error recognition test. Reliability for accurate classification of taps was checked by an independent judge. Number of agreements between the judge and the researcher was divided by the number of agreements plus the number of disagreements and calculated at 95 percent.

SCORING PROCEDURES: KAUFMAN ASSESSMENT BATTERY MEMORY TESTS

Because finger numbers were used as a teaching and learning strategy, questions of concentration and memory were raised. Are children remembering finger numbers only, or are they remembering the motor sequence? To test sequential processing skills, visual-motor coordination, reproduction of a model, and short-term memory, two subtests from the Kaufman Assessment Battery for Children were given, the Hand Movement subtest and the Number Recall subtest. Both tests require short-term memory (visual and auditory respectively), and the ability to reproduce a model, either a sequence of hand movements or a sequence of spoken digits.

I followed the instructions for scoring and scaling these standardized tests according to different age groups (Kaufman & Kaufman, 1983). In order for an answer to be correct, the subject had to tap or say the entire sequence correctly; one wrong hand position or wrong number rendered the entire sequence as incorrect. Reliability for classification of memory test responses as correct or incorrect was performed by an independent judge. The number of agreements between the reliability judge and the researcher was divided by the number of agreements plus the number of disagreements and calculated as 99 percent.

RESULTS

Performance Accuracy Tests

The main purpose of this study was to determine the effects of familiarity and grade on children's note accuracy when playing a keyboard melody. Four analyses were performed on performance accuracy scores, two for scores in Test 1^a (two-measure test) and two for scores in Test 4 (four-measure test). A two-factor ANOVA was performed to test the effects of grade and familiarity on number of correct measures played in Test 1^a. No significant effects were found for grade or familiarity and no significant interaction was found between grade and familiarity.

A two-factor ANOVA was performed to test the effects of grade and familiarity on number of correct notes played in Test 1[a]. No significant effects were found for familiarity or grade. However, when comparing the mean numbers of correct notes played by the familiar and the unfamiliar group, it was found that children in the familiar group played more correct notes than did the children in the unfamiliar group (M = 6.23 and M = 5.55 respectively; maximum possible score = 8). No significant interaction was found between grade and familiarity.

Significant effects were seen, however, for grade and familiarity on performance accuracy in Test 4 (four-measure melody). A two-factor ANOVA was performed to study the effects of age (K, 1, 2, 3, 4) and familiarity (familiar or unfamiliar melody) on the number of correct measures played (Table 3). A significant effect was found for familiarity F (1, 87) = 11.5, p < .01 (Figure 6). Children in the unfamiliar group scored significantly lower than children in the familiar group (M = 1.6 and M = 2.4 respectively). Additionally, a significant effect was found for grade F (4, 87) = 3.41, p = .01 (Figure 7), with Tukey post hoc analysis identifying a significant difference between kindergarten and fourth grade children's scores (p = .04) and between first grade and fourth grade children's scores (p = .03). Fourth graders scored significantly higher than kindergarteners or first graders (M = 2.65, M = 1.47, and M = 1.52 respectively). No significant interaction was found between familiarity and grade.

Table 3: ANOVA for Grade and Familiarity on Correct Measures.

Source	*SS*	*df*	*MS*	*F*	*p*
		Between subjects			
Grade	21.68	4.00	5.42	3.48	.01
Familiarity	13.92	1.00	13.92	8.93	.004
Grade* Familiarity	5.32	4.00	1.33	0.85	.50
Error	135.60	87.00	1.56		

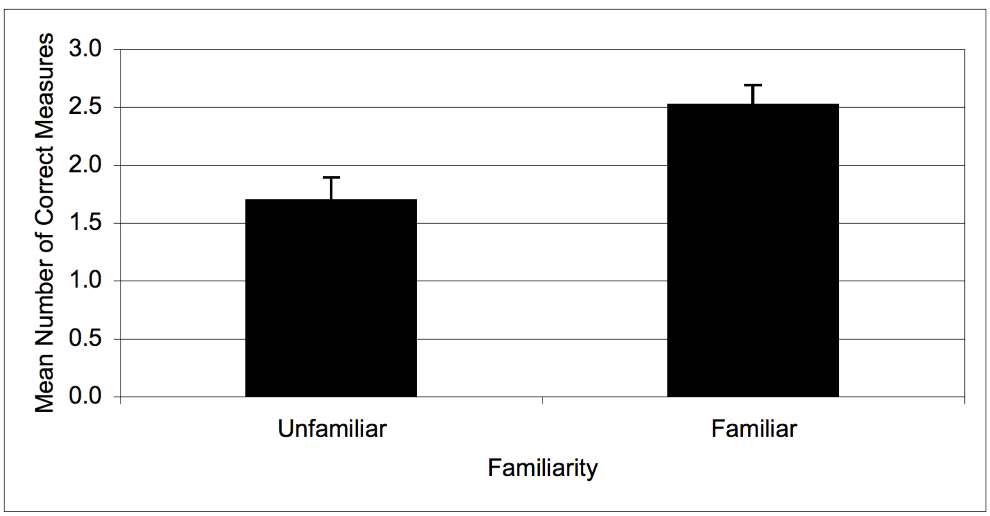

Figure 6: Mean number of correct measures plus standard error for unfamiliar and familiar groups in Test 4 (4-measure sequence).

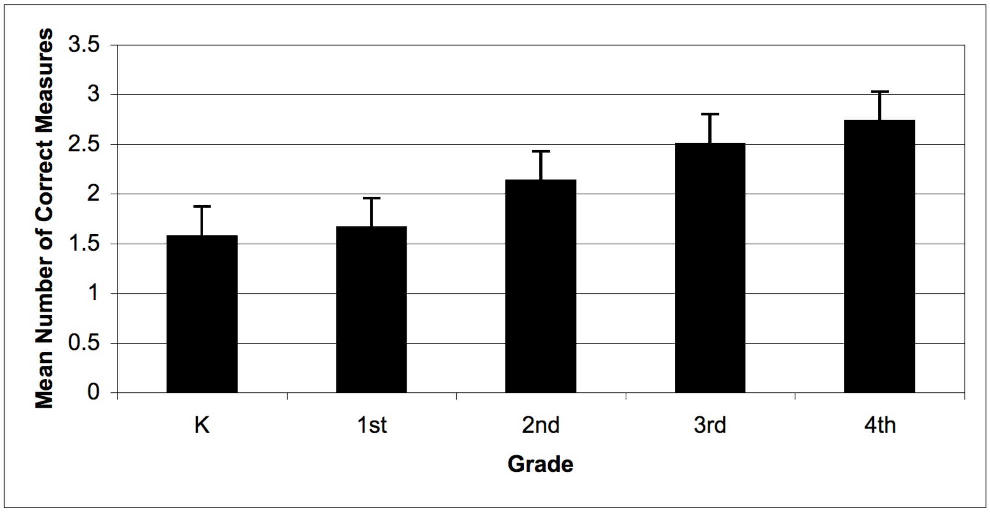

Figure 7: Mean number of correct measures plus standard error played in Test 4 (4-measure sequence) at each grade level.

A two-factor ANOVA comparing the effects of age (K, 1, 2, 3, 4) and familiarity (familiar or unfamiliar) on the number of correct notes children played in the four-measure sequence (Table 4) showed a significant effect of familiarity F (1, 87) = 12.56, p < .01, and grade F (4, 87) = 3.37, p = .01. Children who were familiar with the melody scored significantly higher than children who were not familiar with the melody (M = 11.28 and M = 8.19 respectively; Figure 8). Tukey comparisons indicated a significant difference between the scores of kindergarteners and fourth graders (p = .02), with fourth graders scoring significantly higher than kindergarteners (M = 11.8 and M = 7.71 respectively; Figure 9). No significant interaction was found between familiarity and grade.

Table 4: ANOVA for Grade and Familiarity on Correct Notes.

Source	*SS*	*df*	*MS*	*F*	*p*
		Between subjects			
Grade	246.43	4.00	61.61	3.37	.01
Familiarity	229.86	1.00	229.86	12.56	.00
Grade* Familiarity	76.40	4.00	19.10	1.04	.39
Error	1592.00	87.00	18.30		

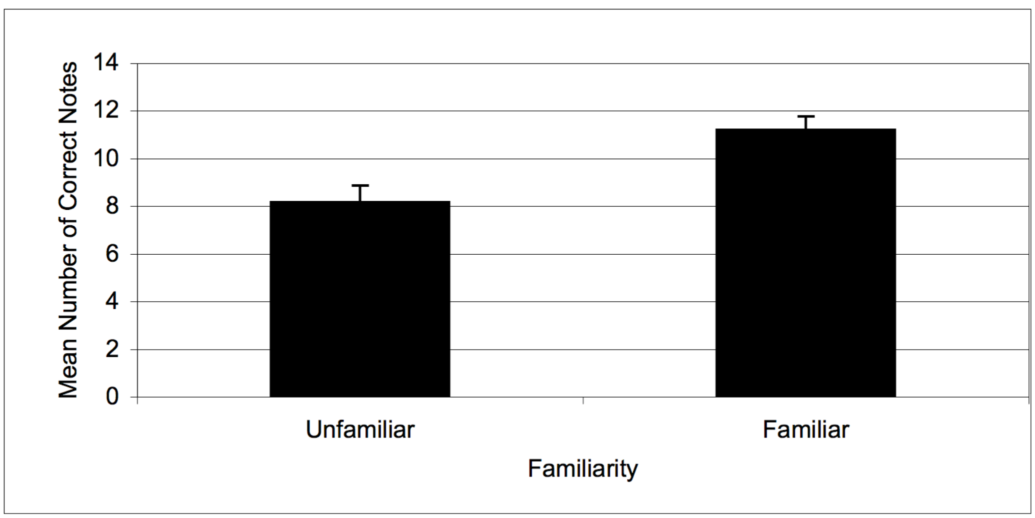

Figure 8: Mean number of correct notes plus standard error in Test 4 (4-measure sequence).

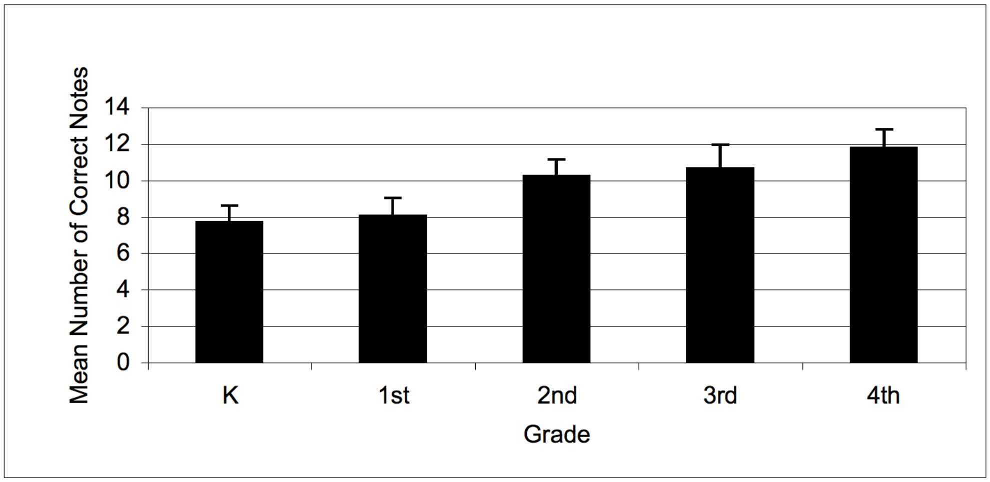

Figure 9: Mean number of correct notes plus standard error played in Test 4 (4-measure sequence) at each grade level.

Sound Feedback

Children played the two-measure sequence in four tests with three types of sound feedback: Test 1^a with sound, Test 2 with no sound, Test 1^b with sound (repetition of Test 1^a) and Test 3 with transposed sound (beginning the sequence on B instead of Middle C). Children repeated Test 1^a (playing the first two measures of the test melody while hearing the sound) after they had played the first two measures without sound (Test 2) to test for learning that may have occurred during the different feedback conditions. An ANOVA with Repeated Measures was performed to test the effects of grade and familiarity on the number of correct notes in Test 1^a and Test 1^b. No significant differences were found between Test 1^a and Test 1^b.

An ANOVA with Repeated Measures was performed to test the effect of grade and familiarity on the number of pitches played when hearing the sound, when not hearing the sound, and when hearing "incorrect sounds" (hearing the melody starting on B instead of Middle C, thereby changing the order of half steps and whole steps; Table

5). A significant effect was found for familiarity *F* (1, 87) = 5.44, *p* = .02. Children familiar with the melody scored significantly higher (M = 6.31) than did children not familiar with the melody (M = 5.30). A significant interaction was found between feedback and grade *F* (8, 172) = 2.12, *p* = .04, (Figure 5). Generally, children improved with increasing grade and there was little difference in performance between the three sound feedback conditions except for fourth graders, who exhibited poor performance with no sound feedback (see Figure 10). No significant main effect was found for grade.

Table 5: ANOVA with Repeated Measures for Grade and Familiarity on Sound Feedback.

Source	*SS*	*df*	*MS*	*F*	*p*
		Between participants			
Grade	83.09	4.00	20.77	1.51	.21
Familiarity	74.78	1.00	74.78	5.44	.02
Grade * Familiarity	57.17	4.00	14.29	1.04	.39
Error	1196.84	87.00	13.76		

Effect	*df*	*F*	*Error df*	*p*
	Within participants			
Feedback	2.00	7.357(a)	86.00	.00
Feedback * Grade	8.00	2.117(a)	172.00	.04
Feedback * Condition	2.00	2.256(a)	86.00	.11
Feedback * Grade * Condition	8.00	.517(a)	172.00	.84

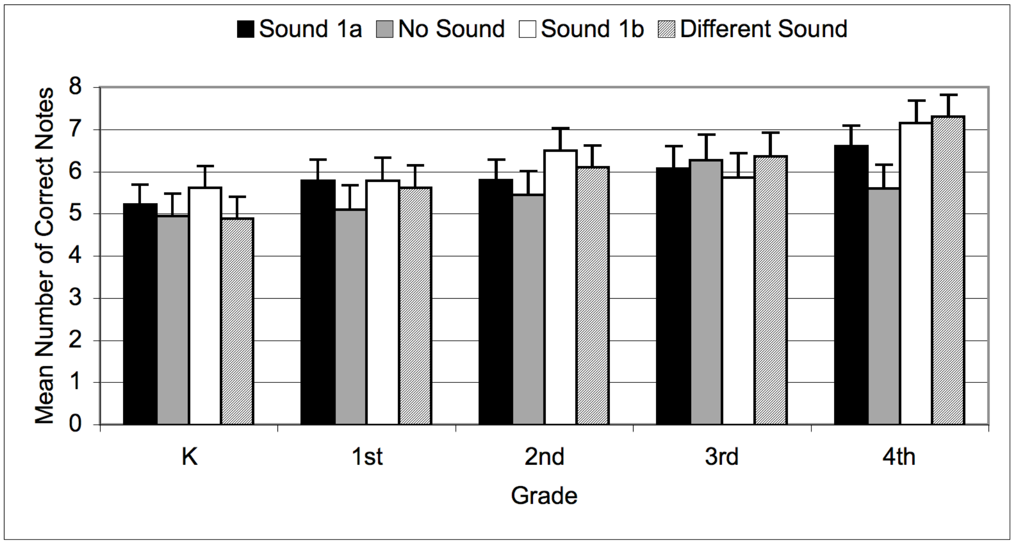

Figure 10: Mean number of correct notes plus standard error in the 2-measure sequence played at each grade level with sound (Test1[a]), no sound, sound (Test1[b]), and transposed sound feedback.

Memory Tests

Participants were taught to play the four-measure sequence using finger numbers (I sang the finger numbers in every model demonstration). Because finger numbers were used, questions of concentration and memory were raised. Do children concentrate on remembering the motor sequence or are they simply remembering finger numbers? To test basic memory abilities, two tests were taken from the Kaufmann Assessment Battery for Children, the Hand Movement subtest to test motor memory and the Number Recall subtest to test ability to remember a number sequence. Each test had a standardized mean score of 10.

Two ANOVAs were performed to test for possible differences in memory between the two groups of children. No significant differences were found between the memory test scores of the familiar and unfamiliar groups. Mean scores on the Hand

Movement test were unfamiliar = 9.9, familiar = 9.3. Mean scores on Number Recall were unfamiliar = 11.9, familiar = 11.6.

To study the relationship between Hand Movement motor memory and note accuracy, a Pearson correlation was performed. No significant correlation was found between number of correct measures played in Test 1[a] and Hand Movement test score ($r = .09$, $p = .40$). Another correlation was performed to study the relationship between number of correct measures played and Number Recall. No significant correlation was found between number of correct measures played and Number Recall (r = .12, $p = .25$). Similarly, no significant correlations were found between number of correct notes played and Number Recall ($r = .104$, $p = .31$). The correlations between memory tests and note accuracy were not only non-significant, but were also very low.

Error Recognition Test

During the Error Recognition Test, participants listened to the test melody with six errors and identified errors by tapping claves. An ANOVA with Repeated Measures was performed to study the effect of grade and familiarity on error identification during the pre-test (at the beginning of the training and testing session) and the post-test (at the end of the training and testing session; Table 6). The analyses showed a significant difference between the total number of correct taps in the pre and post-tests, $F\ (1, 84) = 11.53$, $p < .01$, and a significant effect of familiarity, $F\ (1, 84) = 89.54$, $p < .01$ (Figure 11). Children performed better on the post-test than on the pre-test, and children in the familiar group identified more errors than did children in the unfamiliar group (familiar pre-test, M = 4.2; familiar post-test, M = 4.7; unfamiliar pre-test, M = 1.5; unfamiliar post-test, M = 1.9).

Table 6: ANOVA with Repeated Measures for Grade and Familiarity on Error Identification in Pre-and Post-Tests.

Source	*SS*	*df*	*MS*	*F*	*p*
		Between participants			
Grade (G)	26.35	4.00	6.59	1.68	.16
Familiarity (F)	351.66	1.00	351.66	89.54	.00
G * F	6.31	4.00	1.58	0.40	.81
Error	329.91	84.00	3.93		
		Within participants			
Time (Pre and Post)	10.48	1.00	10.48	11.53	.00
Time (T) * G	4.81	4.00	1.20	1.32	.27
T * F	0.05	1.00	0.05	0.06	0.81
T * G * F	10.44	4.00	2.61	2.87	0.03
Within Error (time)	76.31	84.00	0.91		

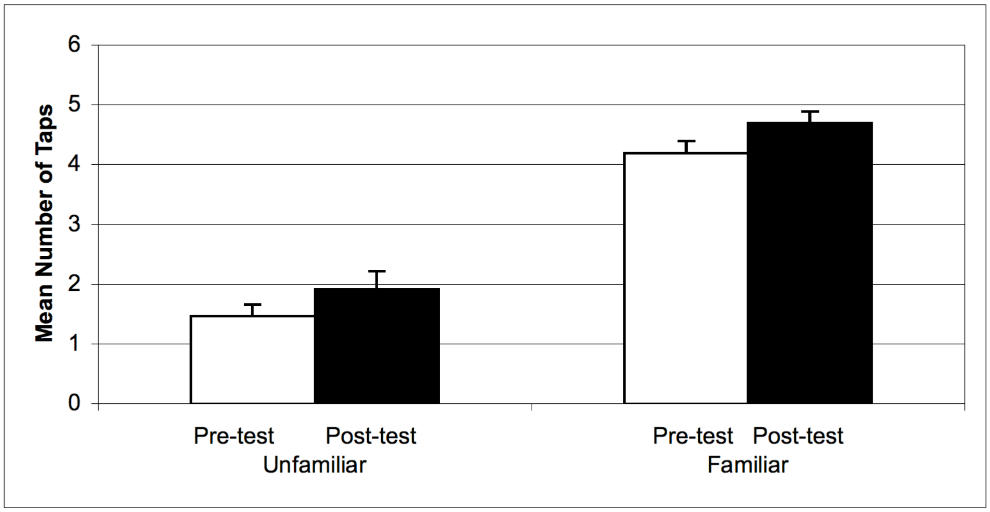

Figure 11: Mean error identification in pre and post-listening test for the unfamiliar and familiar groups.

A significant three-way interaction was found between time (pre- or post-test), grade, and familiarity, F (4, 84) = 2.87, p = .03. Figure 12 presents this interaction. Generally, performance in the post-test was better than performance in the pre-test, the familiar group identified more errors than the unfamiliar group, and similar trends were seen across grades in the pre-test. However, in the post-test, the scores of the unfamiliar group decreased between second and third grades (M = 2.4 and M = 1.9 respectively) while the scores of the familiar group increased (M = 4.4 and M = 5.4 respectively). Additionally, the scores of the unfamiliar group increased between grades three and four (M = 1.9 and M = 2.7 respectively) while the scores of the familiar group decreased (M = 5.4 and M = 4.6 respectively). No other significant interactions were found.

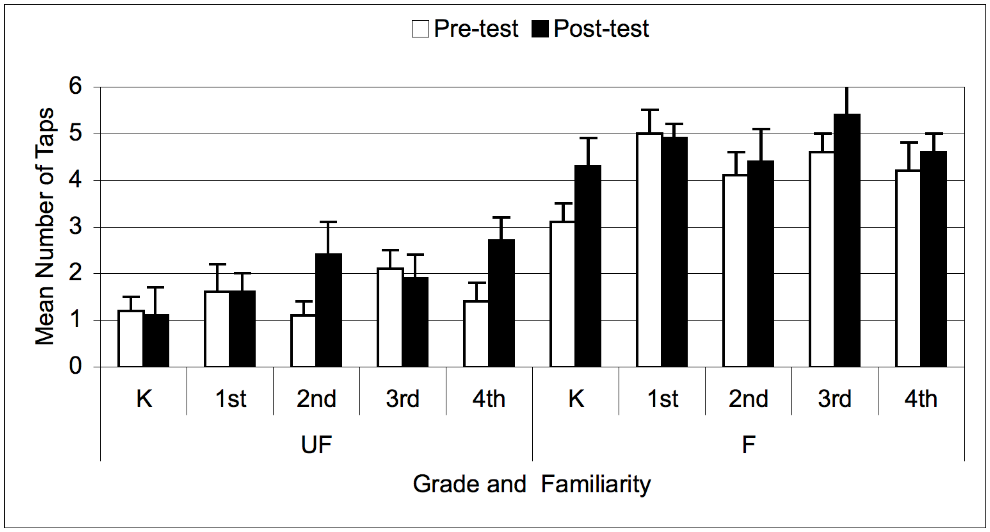

Figure 12: Mean error identification by grade and familiarity (UF = unfamiliar group, F = familiar group) in pre and post-listening test.

In summary, main findings reveal significant effects for grade and familiarity on note accuracy when subjects played all four measures of the test melody. Subjects familiar with the melody played more correct notes and measures than did subjects not familiar with the melody. Note and measure accuracy improved with age. No significant differences were found in note accuracy when subjects played with the sound, without the sound, or with transposed sound, but again, there was a significant effect of familiarity on note accuracy. A significant interaction was found between feedback and grade on the sound tests. No significant correlations were found between number recall ability or hand motor memory and performance accuracy. Children who were familiar with the melody before training and testing began recognized pitch errors more accurately than children who were not familiar with the melody. Overall, children improved in error recognition between the beginning and end of the training and testing session.

Chapter 5: Discussion

The purpose of this study was to examine the effect of familiarity with a model on children's motor skill acquisition in a piano task. The importance of sound feedback in motor learning was also examined. Children (N = 97) in kindergarten through fourth grade were taught to play the test melody, an adaptation of *Perpetual Motion* from *Suzuki Violin Book One*, by rote on the keyboard during a short individual training session. Before training began, children were divided into two groups. The familiar group listened quietly to the test melody during four consecutive music classes prior to training for an accumulated time of approximately eight minutes. The unfamiliar group did not hear the melody before training. The two groups were comparable in terms of memory for digits and memory for hand motions as determined by standardized tests. The group exposed to the melody before training did become familiar with the piece, as shown by a perceptual test that consisted of identifying errors inserted in the melody. Following the training, all children were administered performance tests based on two and four measures of the test melody. The numbers of correct notes and correct measures played by the children were analyzed to identify differences in accuracy between the familiar and unfamiliar groups, between age groups, and between different types of sound feedback (sound, no sound, transposed sound).

Significant effects were found for familiarity when participants played all four measures of the test melody. Children familiar with the melody played more correct notes and more complete correct measures than did children not familiar with the melody. Although all children were taught to play the melody using the same modeling and repetition sequence, children in the experimental group, who were aurally familiar with the melody before they learned to play it, were able to play the melody more accurately than children in the unfamiliar group.

Familiarity with the melody provided children with knowledge of the target response, thereby allowing them to detect errors, self-correct, and persist until they played the correct sequence. It is important to note that in this study, high performance scores are not reflective of errorless performance, but rather are reflective of the ability to eventually achieve an errorless performance or a performance with minimal errors. Consider, for example, the performance of a 7-year-old, first grade female. When attempting to play the four-measure sequence as a whole, she had four false starts, ranging from two incorrect notes to five incorrect notes, before she was able to play the entire sequence correctly. After each false start, she identified the error, with comments such as "oops," "messed up again," or "no." Because she was familiar with the melody, as demonstrated by verbal indication of recognition along with accurate identification of all six errors in the Error Recognition Test, she knew when she played a wrong note. Thus, she persevered until she was satisfied with the accuracy of her performance.

This example is not unusual; similar instances occurred with other participants who were familiar with the melody. Children familiar with the melody compared their own performances to the accurate performances they had heard eight times in music class, whereas the other children only had the teacher demonstration as a reference. As Bandura said, "Most human behavior is learned observationally through modeling" (Bandura, 1977, p. 22). He believed that models serve to give an accurate representation of the skill to be performed, creating a guide for action and reducing the amount of trial and error. In this study, knowledge of the melody gave children a representation of the skill, providing a foundation for better problem-solving through error detection. Although many possibilities exist as to why familiarity with the melody led to more correct notes and measures when playing all four measures of the test melody, it seems that the ability to detect errors was critical for problem-solving, persistence, knowledge of correct and incorrect responses, and eventual accuracy.

Evidence exists demonstrating that children who use problem-solving strategies and self-correct are more successful in their effort to learn to play an instrument than children who do not engage in problem-solving or self-correction (Barry & Hallam, 2002; Costa-Giomi & Sasaki, 2003; McPherson, 2005). In a longitudinal study of children's music learning, McPherson found that the use of problem-solving strategies was crucial for performance success. Older or more advanced students were able to develop and apply a variety of problem-solving strategies, whereas younger children did not have the ability to develop a strategy or use a presented strategy. Barry and Hallam (2002) suggested that when younger children are not aware of the target performance goal through an internal schema or model, they do not have the ability to self-correct. The ability to self-correct seems to be critical for performance success. Costa-Giomi and Sasaki found that piano students who were classified as high achievers after three years of piano lessons exhibited more self-correction and self-reliance strategies in lessons than did students classified as low achievers (2003).

Similarly, Hewitt (2001) found that when participants were engaged in self-evaluation, differences were noticed in performance between the model and no model groups. Listening to a recorded model during self-evaluation improved performance, possibly by enabling more accurate self-evaluation through knowledge of error and the end performance goal. This finding supports the idea that children who were familiar with the test melody were able to detect errors in their own performance, with this self-evaluation leading to improvement in note accuracy. Perhaps prior aural familiarity with the melody enhanced identification of error, knowledge of the target goal and the ability to self-correct. Additionally, perhaps prior aural knowledge provided motivation for children to persevere throughout the task. Video observation of children's performance suggested that students who were familiar with the melody were more willing to keep practicing, even when the music became more challenging.

This explanation for why children who were familiar with the melody played more correct notes and measures than children who were not familiar with the melody can be connected to the importance of familiarity with the "big picture" before practice and learning. In a study of second graders learning to sing a simple folk tune, Klinger, Campbell, and Goolsby (1998) compared familiarity with the "big picture" via modeling of an entire song (immersion) to phrase-by-phrase modeling (part learning). Children who learned by repeatedly singing the entire song performed with fewer errors than children who learned the song one phrase at a time. In the present study, children who were familiar with the melody prior to the training and testing session already had a concept of the "whole" of the test melody before learning the individual "parts" or measures of the piece. Perhaps a prior conception of the entire melody enabled children to construct the entire melody from practice of individual measures. Children who were not familiar with the melody were attempting to put parts together into a whole, without knowing what the eventual whole (goal performance) should sound like.

Furthermore, an aural knowledge of the melody could influence actual finger memory of the sequence. All children were provided with a visual model during training (i.e., watching each model demonstration). Perhaps children who were familiar with the melody were better able to connect their aural memory of the melodic contour of the piece to be learned with the visual contour demonstrated at the piano during the training. For example, knowing that the melody begins by ascending steps could help children decide to move their fingers up in sequential order. The ability to connect the sound of the melody with the visual demonstration of finger movements could be enhanced by having a well-formed knowledge of one aspect (aural familiarity) before introducing the other (physical motor movement).

A significant effect of familiarity was also found in the Error Recognition Test. Participants listened to a recording of the test melody with six errors at the beginning and end of the training and testing session and were asked to tap claves when they heard "something strange, something unexpected, or something weird." Children who were familiar with the melody prior to training and testing correctly identified more errors than children not familiar with the melody prior to training and testing. This finding shows that the familiarization process (listening to the test melody in music class) indeed helped the children learn the melody, enabling them to accurately recognize differences in the melody. Ability to identify mistakes was enhanced by prior familiarity with the melody, both when the children were physically playing and when they were listening. Knowledge of error and self-correction seem to be enhanced by prior aural knowledge.

Children took the Error Recognition Test twice, once at the beginning of the training session and once at the end. Significant differences were found in the total amount of correct taps between the pre-test and the post-test, with children performing more correct taps on the post-test, regardless of familiarity with the melody. Additionally, a significant three-way interaction was found between pre or post-test, grade, and familiarity. Participants in the familiar group always identified more errors than participants in the unfamiliar group. Although performance was generally better on the post-test than on the pre-test, this trend was not always consistent for the unfamiliar group. Kindergarteners and first graders in the unfamiliar group performed similarly on the pre-test and post-test, while second graders and fourth graders showed an improvement between pre and post-test. Although significant differences were found in the total number of correct taps between the pre-test and the post-test, regardless of familiarity with the melody, this three-way interaction may indicate that one session of training was sufficient for older children and children already familiar with the melody (i.e., the familiar group) to discriminate pitch errors, but not sufficient for younger children to do so.

In addition to a significant effect of familiarity, a significant effect of grade was found for note and measure accuracy on children's performance of all four measures. Not surprisingly, older children performed more accurately than younger children, with a significant difference in performance between fourth graders and the two youngest grades, kindergarten and first grade. Perhaps the difference in the effect of modeling on the performance of older and younger children can be explained by musical and cognitive development with age. Investigations that used a wide variety of music tasks show improvement with increasing age. For example, in a harmonic perception task, 8-year-old children were able to discriminate between conclusive and inconclusive cadences and perceive the function of the dominant chord above chance, but 7-year-olds could not (Costa-Giomi & dos Santos, 2001). Likewise, in a study of developmental differences in improvisation, significant differences were found in improvisational strategies between 7- and 9-year-old children, with the older children developing their musical ideas more fully, using more repetition and less exploration during the composition of a short melody at the keyboard (Kratus, 1989). It seems that cognitive strategies in general improve across primary school years as a function of age and experience (Flavell, 1985). General improvement in the ability to concentrate and organize information may explain older children's improved performance in certain music tasks (Costa-Giomi, 2003).

Despite improvements in cognition with increasing age and experience, Moely *et al.* (1992) found that little emphasis was placed on teaching cognitive problem-solving strategies in elementary school. However, they discovered that second and third grade teachers placed more emphasis on metacognition and problem-solving strategies than teachers of younger grades. During second and third grade, children are "unlikely to generate effective strategies in all but very simple learning situations and are relatively unsophisticated in their views of memory processes, but are also very amenable to training in memory strategy use" (Moely, *et al.*, 1992, p. 660). Perhaps the older children in the present study were more developmentally, cognitively, and musically ready for the task, making learning via an aural model particularly effective for them. Younger children, however, were perhaps not able to benefit as much from the model because of their unsophisticated memory processing and limited problem-solving strategies. Older children were more developmentally and cognitively capable of applying previous knowledge of the melody to error detection and correction.

In summary, older children are more capable of effectively applying learning strategies to their work. Improvement (due to age and experience) in cognition, organization, and concentration would allow older children to approach the task more systematically, identify errors, and devise strategies to correct the errors. Older children could rely on the presented strategies (the aural model before training, visual and aural model during training, or use of finger numbers) or could devise their own strategies, whereas younger children could not use the presented strategies or create their own strategies with the same amount of success.

No significant effects were found for grade and familiarity on note or measure accuracy when participants played only the first two measures of the test melody. Perhaps this finding can be explained by the level of difficulty of measures one and two of the test melody as compared to the difficulty level of measures three and four. The first two measures of the test melody are clearly easier than the second two measures because of the arrangement of skips and steps and the repeated use of a pattern (start note, step up, step up, same note). In fact, children made very few mistakes when playing just the first two measures of the piece and a ceiling effect was evident for their performance of these measures. The lack of variability in children's scores in the two-measure test may explain the lack of significant findings in either grade or familiarity for this test.

The contrast between children's performance in the two-measure and four-measure tests is particularly interesting. When children were challenged to play the entire four-measure melody, significant differences were found in grade and familiarity. Aural knowledge of the melody to be learned was influential in the more difficult task. This finding supports current practice in music instruction. Generally, in music lessons and classes, students are presented with and practice larger sections of music. In this study, modeling was most effective when students were presented with more material. This suggests that modeling of entire sections or pieces in music lessons and class would optimize learning.

Another purpose of the study was to explore the effect of sound on note and measure accuracy. Children played the first two measures of the test melody with sound (Test 1^a), without sound (Test 2), with sound (Test 1^b), and with transposed sound (Test 3). Although children familiar with the melody played more correct notes than children unfamiliar with the melody, little difference was found between grades or in note accuracy when children played with different sound feedback (sound, no sound, transposed sound).

The lack of difference in performance when playing with sound, without sound, or with transposed sound could be explained by the simplicity of the task when playing the first two measures of the test melody, the only section of the piece for which the transposed sound feedback conditions were tested. In general, children played the same sequence of notes in all three sound feedback conditions. Once they had learned the sequence, performance was relatively stable across sound feedback conditions, regardless of whether they were playing the sequence correctly or incorrectly. For example, despite a false start in Test 1 and 3, a kindergarten female subject played:

1 2 3 3 2 3 4 4

in Test 1^a, Test 1^b (with sound), Test 2 (without sound), and Test 3 (transposed sound). She played the correct sequence in each test, regardless of type of sound feedback. A first grade male subject played:

3 4 5 5

in Test 1^a, Test 1^b, Test 2, and Test 3. Although each performance was incorrect, his performance was consistent throughout testing and clearly unaffected by the sound feedback. Sound feedback may have had less of an effect on note accuracy if children were simply remembering the physical motion of the sequence. The lack of difference among the two-measure test conditions may suggest that children can rely on their memory of the physical movement when sound feedback is changing or is not available.

Participants were taught to play the four-measure sequence using finger numbers (I sang the finger numbers with every model demonstration). In the initial pilot study, in which finger numbers were not used, children had great difficulty learning the proper note sequence. For this reason, and because standard beginning piano method books use finger numbers as a teaching strategy, finger numbers were used during the training session. Consequently, questions regarding memory and concentration were raised. Do children remember the motor sequence or do they simply remember finger numbers? Are children's memories for number sequences or hand positions related to their ability to perform a sequence on the keyboard? To test basic memory abilities, two tests were taken from the Kaufmann Assessment Battery for Children, the Hand Movement subtest to test motor memory and the Number Recall subtest to test ability to remember a number sequence. Results from the standardized memory tests indicated no significant differences between the familiar or unfamiliar groups in these types of memory and no correlation between number recall ability and note sequence recall or hand movement ability and note accuracy.

Children's reactions to finger numbers were varied. Some children replicated each model by playing and singing finger numbers; others never said or sang the numbers and simply played the note sequence. Younger children seemed to use the finger numbers in the training session more often than older children did, although they were not necessarily accurate in what they said or played. For example, a kindergarten boy in the familiar group played the correct notes for the first two measures while saying the correct finger numbers, but he played the sequence with different (i.e., incorrect) fingers. In other words, he played the correct notes: C D E E D E F F but used the wrong fingers: 2 3 4 4 3 4 5 5. From the repeated observation of the training videos, I noticed that the older children who did use the finger numbers actually played with the fingers they were saying more often than did younger children.

Generally, children who were able to play the entire four-measure sequence did not sing or say finger numbers in that test. Children often began to use the finger numbers when they started struggling, particularly in measures three and four of the test melody. For example, a kindergarten girl did not sing finger numbers while practicing the first two measures but immediately started singing the numbers with the presentation of the third measure (3 4 5 3).

For this task, learning can be attributed in part to an interaction of three associations: the finger numbers, the physical motion of playing the sequence, and the sound of the keyboard. Children may have used these associations differently or selectively. For some children, finger numbers may have been a particularly useful association in the initial learning of the melody and as mistakes occurred. Others may have relied more on the feeling of physically playing the sequence to attain accuracy, without attending to the finger numbers or sound. Still others, particularly children who were familiar with the melody, may have relied on correct and incorrect sounds from the keyboard to guide their physical movement.

It is possible that the use of finger numbers interfered with the learning of the children in the unfamiliar group. These children, having no previous aural knowledge of the melody, could have focused more of their attention on remembering the finger numbers than on the sound of the correct notes, and been unable to allow the sound to direct their movement. Or, children who were not familiar with the melody may not have been able to form an association between finger numbers and the sound of the correct notes, since they were not previously familiar with the sound. Finger numbers may have been more helpful for children who were already familiar with the melody, by providing an additional association to supplement their use of sound feedback or the feeling of the motor movement. Much can be discovered about children's learning and problem-solving strategies by observing them practice. More detailed and precise analyses of their use of finger numbers during training and testing may provide valuable implications for teaching.

Observation of children's reactions and comments during the training session corroborates the main findings, particularly the significant effect of grade on performance. All participants were able to complete the training and testing session, but kindergartener's and first graders seemed to lose focus and concentration as the session progressed, to a greater extent than did the older children. Although children made few comments about the length of the session, I noticed that younger children seemed to tire and become less attentive as the training session progressed. Younger children's changing facial expressions and increasing restlessness indicated their loss of focus.

From an observational standpoint, the performances of children in the familiar group seemed more accurate than the performances of children not familiar with the melody. My perception was that children who were familiar with the melody before training seemed to be less frustrated and more successful. Although the amount of time spent in training was not a dependent measure, particularly considering that everyone played the same number of repetitions, I noticed that the older children, especially those in the familiar group, seemed to move through the training and testing faster, with total times averaging between 13 to 15 minutes, as opposed to 18 to 20 minutes for the younger children. The difference in training and testing times was a result of the older children needing fewer explanations than the younger children and being able to respond immediately to the model. Based on my subjective observation of the training session, familiarity with the melody seemed to prompt faster response times with the older children.

Several comments from children were especially telling about differences between the familiar and unfamiliar groups. When asked to play the entire four-measure melody, a first grade boy in the familiar group said, "I have an idea. When we add on a new one [meaning new measure], why don't I play all of them together?" This same child frequently tried to keep playing, even when the model was only one or two measures long. For this subject, knowledge of the melody made him realize that he was only practicing small parts of the whole melody, and he wanted to keep learning the entire song rather than practice parts.

Although most participants in the familiar group recognized that the song they listened to in the Error Recognition Test was the same as the song they practiced, several children's comments were more insightful. One third grade boy said "Hey! That's the song I just played but why does it have wrong notes?" Comments such as these indicate that familiarity with the melody before practicing the melody influences children's learning.

IMPLICATIONS FOR MUSIC EDUCATION

Based on the results of this study, it is possible to assert that music listening and modeling in the classroom contribute to children's learning of music skills. Frequent exposure to music to be learned, through teacher demonstrations or recordings, helps children gain an aural familiarity with the music and aids the performance of the piece. Understanding the performance goal can lead children to detect errors and self-correct when performing a piece. Greater note accuracy in the performance of children who become familiar with the music before learning to play is a finding that instrumental teachers may deem valuable.

Although modeling has long been part of the Suzuki methodology and classroom music education, modeling has not been used extensively or systematically in piano methods. Effective teachers model often in their lessons (Colprit, 2000; Duke, 1999; Duke & Simmons, 2004; Siebnaler, 1997), yet, in most beginning piano methodologies (except for the Suzuki piano method), familiarity with a melody and teacher modeling is not emphasized. Beginning piano students generally start by learning correct body and hand position and basic rhythms and notes. But developing aural understanding is also an important part of the early learning process.

FUTURE RESEARCH

Findings from this study suggest many directions for future research. Future research may focus on the effect of modeling on other measures of children's performance success. In this study, performance was measured by the number of correct notes and correct measures played. However, playing correct notes or measures represents only one of the many things musicians learn through practice. Professional musicians play correct notes, but also incorporate rhythm, technique, and nuances, such as dynamic changes, tempo changes, and other expressive elements into their performances. Accomplished musicians present accurate, fluid, and confident performances. How does familiarity with a melody affect other performance measures, such as confidence or fluency? How does "correctness" factor into the interpretation of the quality of a performance? Future studies should investigate the effects of familiarity on other performance measures.

Further study of the problem-solving strategies of children of different ages is warranted. Specific analysis of the types of strategies children use when learning to play a melody on the keyboard could deepen our understanding of children's learning and demonstrate why modeling seems to be an effective technique. Differences between the strategies of children who are and are not familiar with the melody to be learned and how strategies differ across age could also be explored.

A replication of the present study with more advanced learners could provide evidence of the role of modeling in relation to the level of the learner. Perhaps the effectiveness of modeling is dependent upon the expertise of the learner. Or, perhaps modeling is effective for all ages and levels but its usefulness changes with differing task complexity. In motor research, modeling prior to practice and in the early stages of practice was found to be more effective than modeling that occurred in later practice sessions (Weeks & Anderson, 2000). Similarly, in music research, modeling prior to practice was found to be more effective for younger participants (Thomas, Pierce, & Ridsdale, 1977). Further exploration of modeling in music comparing simple and complex task learning and different levels of learning is needed.

The role of sound in motor learning should be studied to determine the ways that sound feedback changes motor performance. Sound feedback is an intrinsic aspect of every music performance, yet its relation to motor learning in music situations is poorly understood. In this study, no significant differences were found in children's note accuracy when hearing sound, no sound, and transposed sound feedback in a relatively simple task. Future investigations could examine this finding with more complex tasks. Additionally, in the present study, all children learned to play the melody while hearing the sound. Comparing performance accuracy in retention and transfer when participants practice with and without the sound may provide valuable information for musicians and music teachers.

Research focusing on the effect of different types of modeling on children's performance accuracy could present implications for music teaching. Perhaps the idea of awareness of the big picture of learning, used in previous studies where children learn to sing a song and used by Suzuki-trained teachers, could be explored with a piano task.

Further study of these questions and others will deepen our understanding of children's music learning and the role of motor skill development and acquisition in instrumental learning. Modeling has been demonstrated to be an effective instructional technique in this and many other studies. Further research investigating different types of modeling, modeling with learners of different levels, modeling with more simple or complex tasks, and the effect of modeling on different measures of success will contribute to our growing knowledge of children's music learning. Additionally, further study of the role of sound in motor learning will contribute to these goals. Investigation of the use of modeling in children's music learning and the motor components associated with music learning will hopefully lead to greater understanding of children's learning and effective instructional techniques.

Appendix A: Parent Information Letter

Dear Parents,

We would like to invite your child to participate in a study of music learning and motor development conducted at the School of Music of The University of Texas. We are interested in learning more about children's first attempts at playing a familiar and an unfamiliar tune at the piano. Our hope is that by understanding better how children develop the motor and musical skills required to perform an instrument, we will be able to provide teachers and parents with appropriate guidelines for effective and pleasurable music learning.

In this project, we will look at how children without previous music instruction practice a simple musical tune on a piano. If you allow your child to participate, s/he will receive 10 - 20 minutes of individual piano instruction with Katie Goins, a doctoral student in Piano Pedagogy at UT. This short lesson will take place at the school during music class and it will be videotaped for analysis. During the lesson, your child will listen to the teacher play and to a recording of the piece, and will have multiple opportunities to play the piano. By the end of the lesson, your child will be able to play the melody from memory. Prior instrumental experience is not necessary. The lesson will be enjoyable and fun; however, the teacher will stop the lesson at any time if your child so desires. The data gathered from your child will remain confidential, your child's name will not be associated with the data, and the data will be used for research purposes only.

We believe that this project will be stimulating for your child and will have clear implications for the education of children. Please return the attached consent form to Heidi Kaim as soon as possible. If you have further questions, please contact Katie Goins at katiegoins@mail.utexas.edu, 512-585-7491, Dr. Costa-Giomi at costagiomi@mail.utexas.edu, 512- 471-2495, or Heidi Kaim at hkaim@eanes.k12.tx.us. Further questions about your child's ethical treatment in this research study may be directed to Clarke Bunham, Ph.D. at 512-232-4384. He is the chair of the University of Texas committee that oversees the ethical aspects of research with human participants.

We thank you for your consideration and look forward to working with your child.

Sincerely,

Katie Goins	Eugenia Costa-Giomi, Ph.D	Heidi Kaim
Doctoral Candidate	Associate Professor	Music Teacher
Music and Human Learning	Music and Human Learning	Cedar Creek
UT-Austin	UT-Austin	Elementary School

Appendix B: Parental Consent Form

Your child is invited to participate in a study of children's motor skill acquisition in a music task. I am a student at the University of Texas at Austin and I work with Eugenia Costa-Giomi in the department of Music and Human Learning. Your child may be one of approximately 125 children participating in this study.

This experience will augment your child's classroom music with private piano instruction. Indirect benefits will include an increased understanding of musical and motor development, with potential applications to the field of music education. Any information in this study that is identified with your child will remain secured in the investigator's office, will be used only for research purposes, and will be disclosed only with your permission. Your decision to participate or not participate will not affect you or your child's future relations with The University of Texas.

I have read the information provided above and permit my child to participate. My child may discontinue participation in this study at any time for any reason regardless of having signed this form. (If you so desire, you will be offered a copy of this form to keep.)

____________________________________ __________
Signature of Parent or Legal Guardian Date

___________________________________ __________ ___________
Child's Name Grade Birthday & Age

Please tell us about your child's prior music experience.

Has your child taken music lessons? Yes / No
Instrument: _____________
For how long? ________

Has anyone in your home taken music lessons? Yes / No
Who: _______________
Instrument: ___________

Does this person still play? _______________

Do you have a piano or keyboard in your home? Yes / No

Appendix C: Student Assent Form

I agree to be in a study about learning music by listening and playing the piano. This study was explained to my (mother/father/parents/guardian) and (she/he/they) said that I could be in it. The only people who will know about what I say and do in the study will be the people in charge of the study.

In this study, I will be asked to listen to a song recording and answer questions about what I hear. I will also try to play the song on the piano.

Writing my name on this page means that the page was read (by me/to me) and that I agree to be in the study. I know what will happen to me. If I decide to quit the study, all I have to do is tell the person in charge.

______________________________________ ____________________
Child's Signature Date

______________________________________ ____________________
Signature of Researcher Date

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